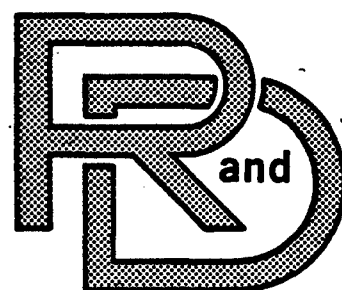


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LABORATORY

TECHNICAL REPORT

NO. 12909

MILITARY ADAPTATION OF COMMERCIAL ITEMS (MACI)

LABORATORY EVALUATION OF THE CODE E-436 ENGINE

February 1984



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by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The project determined the military adaptability of the Code E-436 engine through laboratory testing and evaluation. The engine was installed in a dynamometer test cell at US Army Tank-Automotive Command (TACOM) and conventional dynamometer testing procedures were used to determine basic engine characteristics. The characteristics determined were full load performance, fuel economy at full load and part load, engine oil consumption, and engine heat rejection.		

During pre-endurance testing, the Code E-436 engine produced 378 observed kW (506.4 BHP) at full load, at rated speed of 2600 RPM. The maximum torque during full load operation was 1439 Nm (1061 lb-ft) at 2400 RPM. Minimum brake specific fuel consumption at full load occurred at 2200 RPM and was 217 g/KWH (0.356 lb/BHP-HR).

After the NATO Endurance Test the engine produced 375.1 observed kW (503.0 BHP) at full load and rated speed. The maximum torque was 1423.8 Nm (1050 lb-ft) at 2400 RPM.

The total lube oil consumption during the 400-hour NATO endurance was 19.7 kgs (43.4 lbs).

Following the endurance test visual and dimensional inspection of the engine revealed all major engine parts to be in excellent condition except for pistons. Five out of eight pistons developed cracks in the pin bores.

Though the engine completed the endurance test (400 hours) and was operated for a total of 582 hours, the engine is considered as having failed the 400-hour NATO test due to piston failure.

PREFACE

This test program was supervised and conducted by the US Army Tank-Automotive Command, R&D Center, Propulsion Systems Division, in test cell no. 6 of Bldg. 212. The test was started on 17 Jan 83 and was completed on 28 Jul 83.

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1.0. INTRODUCTION

TACOM started an engineering program in 1975 at the Propulsion Systems Laboratory for Military Adaptation of Commercial Items. The program's objectives are selection and simulated field test evaluation of current advanced technology engines to replace or update military engines in current vehicle programs.

2.0. OBJECTIVE

The test objective is to determine full- and part-load performance characteristics and engine durability through the standard 400-hour NATO Test program (AEP-5 dated June 1980) using fuel with high sulfur content (1.05 percent).

3.0. CONCLUSIONS

The engine performed satisfactorily over the full range of test speeds, both at full and part loads, and throughout the 400-hour endurance test. The engine also met manufacturer's listed performance values of power, torque, fuel economy, and heat rejection. The engine was operated for a total of 582 hours.

Although the engine performed satisfactorily and met the performance requirements, it did not meet durability requirements and therefore failed to pass the 400-hour NATO Test. Failure to pass the NATO Test was based on condition of the pistons at endurance test conclusion; five of the eight pistons had developed serious cracks in piston pin bores.

4.0. RECOMMENDATIONS

Further piston durability improvements would appear obtainable through the following:

- o Material improvement;
- o Change of fabrication methods;
- o Improved piston cooling;
- o Piston reinforcement or addition of another reinforcement material (insert);
- o Heat bridges added or other stress relieving methods applied.

5.0. ENGINE SPECIFICATIONS

5.1. Test Material.

5.1.1. Engine

- o Code: E-436
- o Model: VTA-903T

- o Maximum Output @ 500 ft and 85°F (152m & 29°C) - BHP (kW): 500 (373)
 - o Speed @ Maximum Output - RPM: 2,600
 - o Type: Compression Ign; 4 cycle; 90° Vee; 8 Cylinder
 - o Aspiration: Turbocharged & Aftercooled
 - o Bore-in (mm) x Stroke-in. (mm): 5.5 (140) x 4.75 (121)
 - o Displacement - in³ (litres): 903 (14.8)
 - o Compression Ratio: 15.5:1
 - o Dry Weight (with Standard Accessories) - lb, (kg): 2,450 (1,110)
 - o Piston Cooling: Drilled Rods
- 5.1.2. Lubricating Oil: Grade 30, MIL-L-2104-C
Referee Grade: 30
Imperial Oil Co.
(APPENDIX E)
- 5.1.3. Fuel: MIL-F-46162B (ME) (14 Aug 81)
0.95-1.05 percent Sulfur by Weight
(APPENDIX B)
- 5.2. Test Equipment. Controls equipment, and associated instrumentation of cell no. 2, Building 212 TACOM.
- 5.3. Test Procedure.
- 5.3.1. Propulsion Systems Division Test Program: Engine Operating Limits and Adjustments. (APPENDIX A)
- 5.3.2. NATO Test Specification: Allied Engineer Publication (AEP-5) June 1980, NATO Standard Engine Laboratory Test for Gas Turbine Engines and Diesel and Gasoline Engines. (APPENDIX D)
- 6.0. RESULTS AND DISCUSSION
- 6.1. Pre-endurance Test Performance Evaluation.
- 6.1.1. Full-load Performance. All data are presented as observed without corrections. The engine developed 378 observed kW (506.4 BHP) at its rated speed of 2,600 RPM. Peak torque was 1,439 N-m. (1,061 lb-ft) at 2,400 RPM. Performance details are presented in Figures 1 and 2 and Table 1.
- 6.1.2. Part-load Performance. The minimum observed brake specific fuel consumption was 215 g/kW-hr (0.354 lb/HP-hr) at 1,900 RPM, at 85 percent load.
- 6.2. Performance and Endurance Evaluation During NATO Test.
- 6.2.1. Full-load Performance After 100 Hours. The engine developed 377.2 kW (505.9 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,443

N-m. (1,064 lb-ft). Performance details are presented in Figures 3 and 4 and Table 2.

6.2.2. Full-load Performance After 200 Hours. The engine developed 377.2 kW (505.9 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,441.4 N-m. (1063 lb-ft). Performance details are presented in Figures 5 and 6 and Table 3.

6.2.3. Full-load Performance After 300 Hours. The engine developed 376.6 kW (505 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,430.6 N-m. (1055 lb-ft). Performance details are presented in Figures 7 and 8 and Table 4.

6.2.4. Full-load Performance After 400 Hours. The engine developed 375.1 kW (503 BHP) at 2,600 RPM. The maximum torque value was 1,423.8 N-m. (1050 lb-ft) at 2,400 RPM. Performance details are presented in Figures 9 and 10 and Table 5.

6.2.5. Endurance Test (400 Hours). Although the engine completed the endurance test (400 hours) and was operated for a total of 582 hours, the engine failed the NATO Test.

6.2.6. Visual and Dimensional Inspection of Major Engine Components Following Endurance. At completion of the test, the engine was completely disassembled, and cleaned and all critical parts were visually examined, dimensionally checked, and photographed. Visual inspection and measurements revealed that virtually all components were in excellent condition. The engine components and their condition are described as follows (see APPENDIX F for photographs and APPENDIX G for Dimensional Inspection Sheets):

- o Pistons - Pistons and rings showed no evidence of scoring. Rings had no breakage and were free to move in the ring grooves. Ring grooves were still tight. Piston skirts were clean - no signs of varnishing. Varnish was only evident on the bottom side of the piston heads where cooling oil made contact.

Although the outward appearance of the pistons was good, six pistons showed signs of severe stress. Cracks had developed in the piston pin bosses in the upper half of the wrist pin bores. Piston numbers 1 and 8 did not show signs of cracking. Carbon buildup on pistons and top lands was light.

- o Piston Pin - No visual wear.
- o Cylinders - Good appearance with only minimal wear indicated.
- o Crankshaft Main Journals - Very good condition.
- o Crankshaft Rod Journals - Very good condition.
- o Main and Rod Bearings - No scratching and no overlay breakthrough.
- o Cylinder Head Intake and Exhaust Valve Seats - Very good condition.
- o Intake and Exhaust Valve Faces - Good condition.
- o Camshaft - Lobes and bearing surfaces were in excellent condition.

- o Gears - Crankshaft, Camshaft, Oil Pump Drive and Injection Pump Drive - good condition with no scratching or scoring.

- o Oil Pump Pickup Tube - Broken at the bottom end near the pan - did not prevent oil pickup.

- o Engine Torsional Vibration Damper - Showed signs of fatigue failure - some of the elastomer worked loose.

6.2.7. Engine Oil Consumption. Oil consumption during the test was recorded by using the method of adding oil to the engine as required before engine start-up. Oil consumption was light. Results are shown in Table 6.

6.2.8. Oil Spectrographic Analysis. Oil samples were taken at 25-hour intervals and forwarded to the Petroleum Field Office East, New Cumberland, Pennsylvania. Report findings met NATO requirements as shown in APPENDIX E. (Oil sampling analysis was started at 126.5 hours).

6.2.9. Full-load Heat Rejection. Maximum full-load Brake Specific Heat Rejection measured 0.585 W/W (24.8 BTU/BHP-MIN) at rated speed, 2,600 RPM. The total heat rejected was 217.3 kW (12,356 BTU/MIN). Full-load heat rejection characteristics are shown in Figures 11 and 12.

6.2.10. Neither Smoke Readings nor Full-load Air Flow Were Measured. However, some data from a previously tested engine of the same model have been added to this report for general informational purposes. These data are shown in Figure 13 and Table 7.

6.2.11. Fuel Map - Data are shown in Figure 14.

6.2.12. Performance Data Sheets Required by NATO Specifications. Data are shown in APPENDIX H.

SUPPLEMENTARY NOTE: THE ILLUSTRATION AND TABLES IN PAGES 16 THROUGH 33
ARE ARRANGED IN THE FOLLOWING FORMAT:

ILLUSTRATION (METRIC UNITS)

ILLUSTRATION (ENGLISH UNITS)

TABLE (ENGLISH AND METRIC UNITS)

ILLUSTRATIONS HAVE DUPLICATE TITLES BUT DO NOT PRESENT DUPLICATE VALUES.

FIGURE 1
ENGINE FULL LOAD PERFORMANCE (0 HOURS)

OBSERVED TORQUE (N-m.)

1450

1350

1250

1150

OBS. BSFC (g/kWh)

250

210

1400

1600

1800

2000

2200

2400

2500

ENGINE SPEED - RPM

OBSERVED POWER (kW)

400

320

240

160

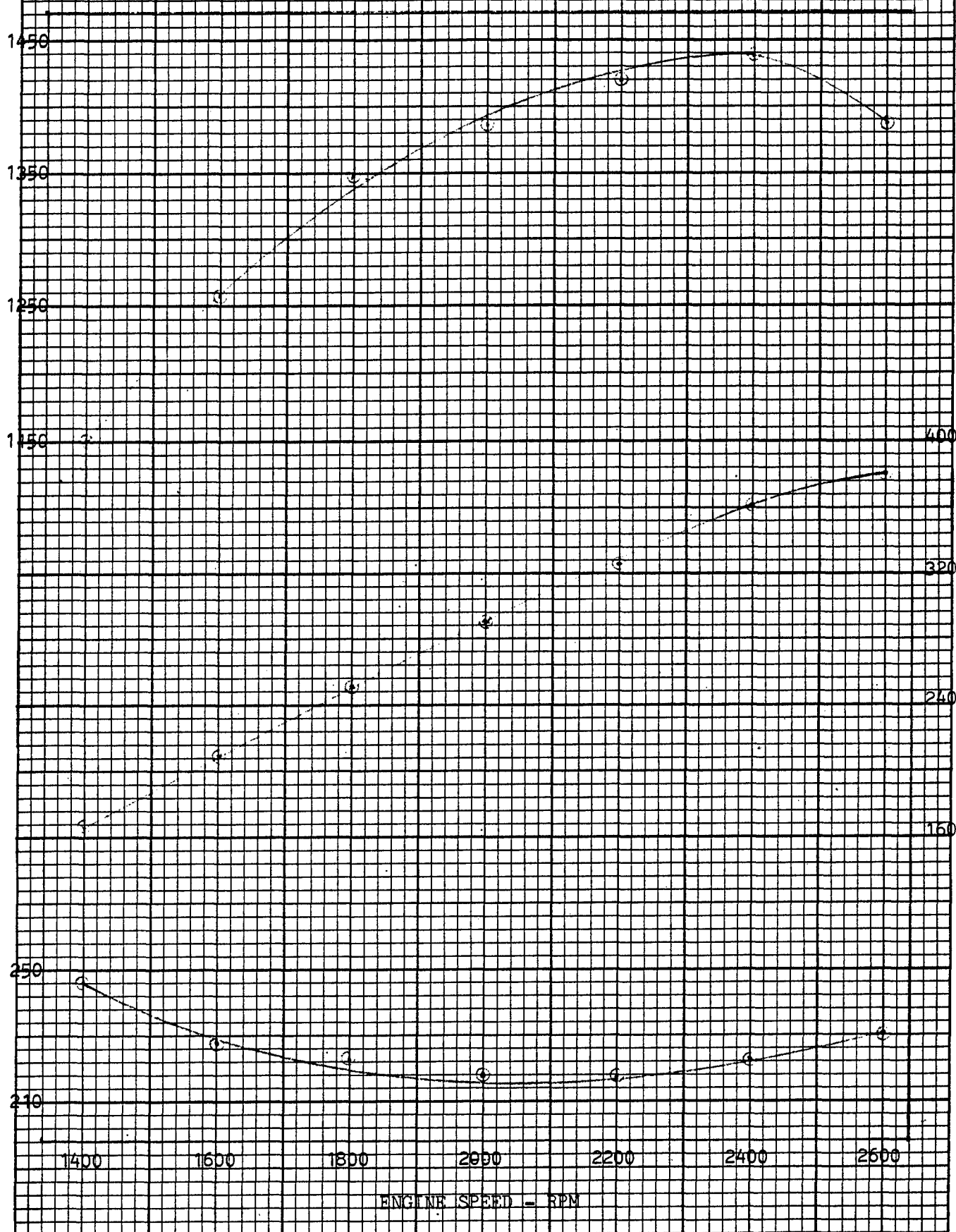


FIGURE 2
ENGINE FULL LOAD PERFORMANCE (0-HOURS)

OBSERVED TORQUE (LB-FT)

1100
1000
900
800

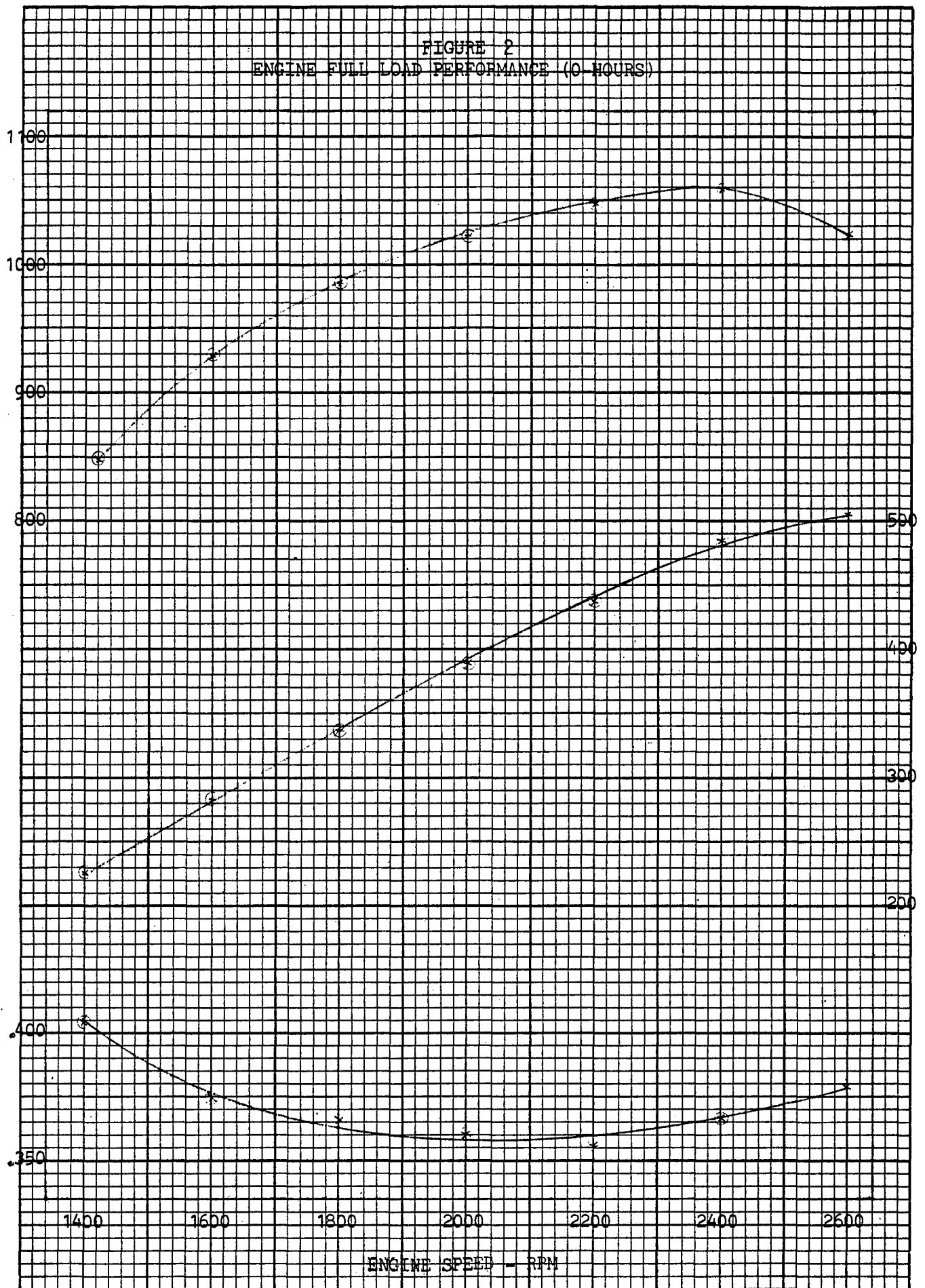
OBS. BSFC (LB/BHP-HR)

400
350

OBSERVED POWER (HP)

500
400
300
200

ENGINE SPEED - RPM



Code E-436 Engine Full Load Performance Data
Before Endurance - 0 Hours

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP OF (°C)	AIR CLEANER OUTLET TEMP OF (°C)	FUEL TEMP TO ENGINE OF (°C)	ENGINE COOLANT OUTLET TEMP OF (°C)
2,600	1023 (1387)	506.4 (378.0)	191.84 (87.02)	0.379 (231)	261 (127.2)	84 (28.9)	87 (30.6)	201.6 (94.2)
2,400	1061 (1439)	484.8 (362.0)	171.76 (77.91)	0.367 (223)	259 (126.1)	86 (30.0)	86 (30.0)	202.1 (94.5)
2,200	1047 (1420)	438.5 (327.0)	156.22 (70.86)	0.356 (217)	257 (125.0)	86 (30.0)	88 (31.1)	201.7 (94.3)
2,000	1022 (1386)	389.1 (290.0)	139.72 (63.38)	0.359 (218)	254 (123.3)	86 (30.0)	86 (30.0)	201.8 (94.3)
1,800	984 (1334)	337.4 (252.0)	123.55 (56.04)	0.366 (223)	252 (122.2)	86 (30.0)	86 (30.0)	201.9 (94.4)
1,600	928 (1258)	283.4 (211.0)	106.43 (48.28)	0.376 (228)	249 (120.6)	85 (29.4)	85 (29.4)	202.2 (94.6)
1,400	849 (1151)	226.6 (169.0)	91.48 (41.50)	0.404 (246)	247 (119.4)	85 (29.4)	85 (29.4)	202.1 (94.5)

Applicable Test Conditions/Range Variations

Intake Air Restriction -4.6 to -5.8 in. H₂O (96.9 to 97.9 kPa)
Exhaust Gas Outlet Pressure +15.3 to .57 in. H₂O (101.9 to 98.2 kPa)

Dry Air Barometer: 28.77 -in. Hg (97.4 kPa)

TABLE 1

FIGURE 3
ENGINE FULL LOAD PERFORMANCE (100 HOURS)

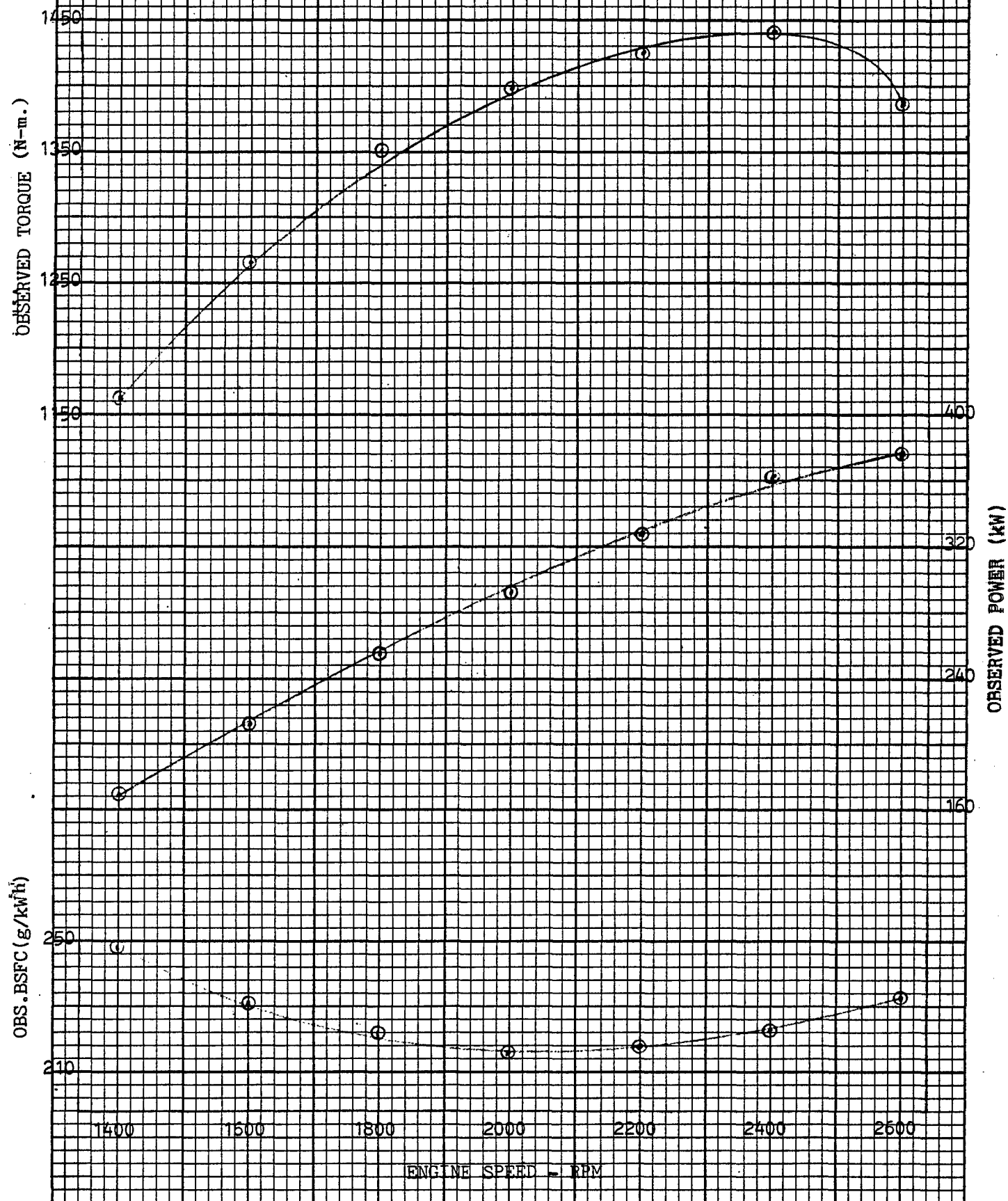
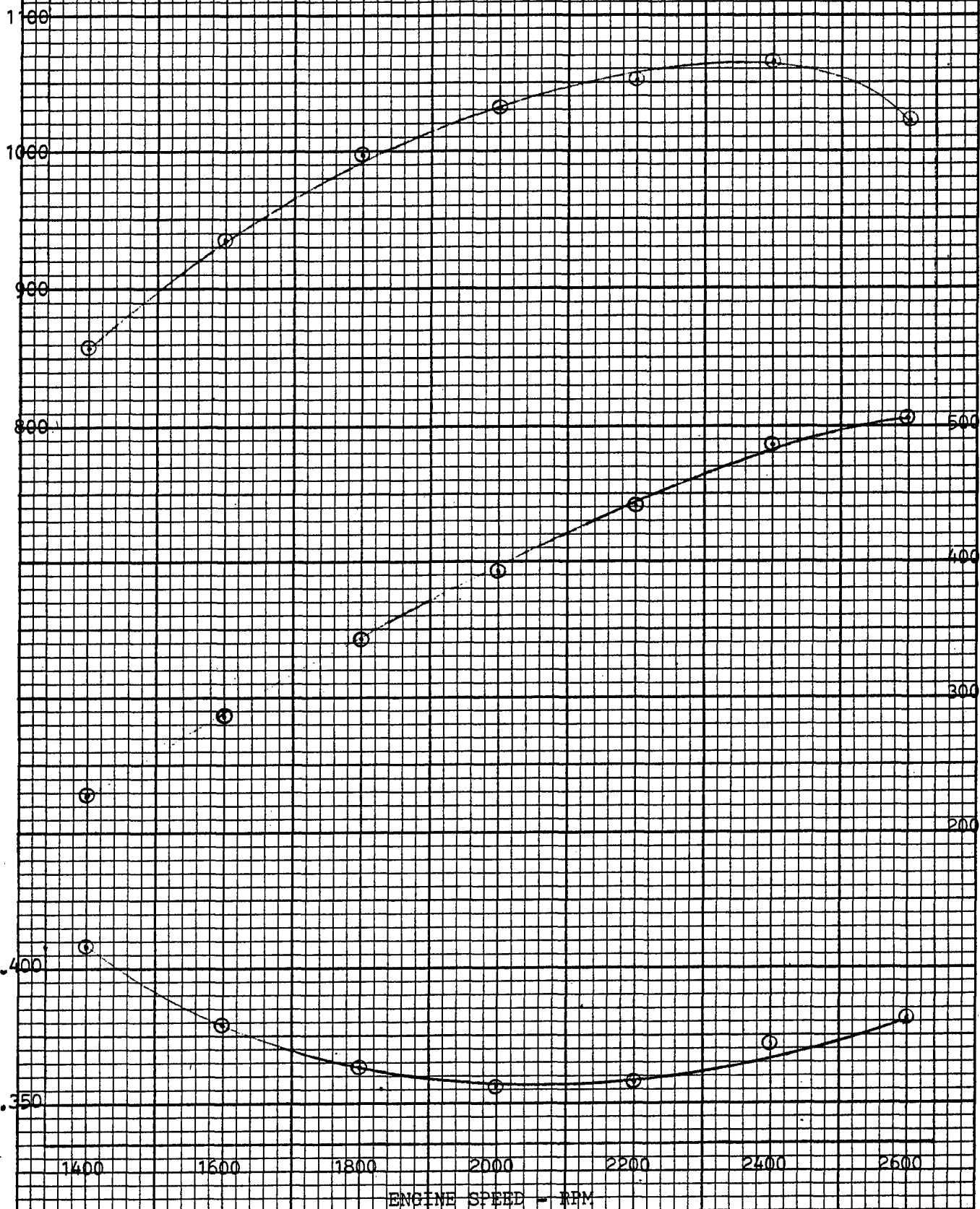


FIGURE 4
ENGINE FULL LOAD PERFORMANCE (100 HOURS)

OBSERVED TORQUE (LB-FT)

OBSERVED POWER (HP)

OBS. BSFC (LB/BHP-HR)



Code E-436 Engine Full Load Performance Data

After 100 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP OF (°C)	AIR CLEANER OUTLET TEMP OF (°C)	FUEL TEMP TO ENGINE OF (°C)	ENGINE COOLANT OUTLET TEMP OF (°C)
2,600	1022 (1386)	505.9 (377.2)	193.78 (87.90)	0.383 (232.9)	260 (126.7)	78.7 (25.9)	80.4 (26.9)	202.2 (94.6)
2,400	1064 (1443)	486.2 (362.6)	178.52 (80.98)	0.367 (223.2)	256.8 (124.9)	74.2 (23.4)	82.5 (28.1)	200.7 (93.7)
2,200	1051 (1425)	440.3 (328.3)	157.45 (71.42)	0.358 (217.8)	253.9 (123.3)	75.0 (23.9)	84.5 (29.2)	200.5 (93.6)
2,000	1031 (1398)	392.6 (292.8)	139.58 (63.31)	0.356 (216.6)	252.2 (122.3)	76.8 (24.9)	82.4 (28.0)	201.8 (94.3)
1,800	997 (1352)	341.7 (254.8)	124.54 (56.49)	0.364 (221.4)	250.1 (121.2)	76.8 (24.9)	82.5 (28.1)	201.7 (94.3)
1,600	934 (1267)	284.5 (211.9)	107.87 (48.93)	0.379 (230.5)	247.6 (119.8)	79.1 (26.2)	86.9 (30.5)	201.5 (94.2)
1,400	857 (1162)	228 (170.3)	93.06 (42.21)	0.407 (247.6)	245 (118.3)	79.5 (26.4)	84.1 (28.9)	201.9 (94.4)

Applicable Test Condition/Range Variation

Intake Air Restriction -5.3 to -1.2 in. H₂O (96.7 to 97.8 kPa)

Exhaust Gas Outlet Pressure 14.3 to .8 in. H₂O (101.6 to 98.3 kPa)

Dry Air Barometer: 29.08 in. Hg (196.5 kPa)

FIGURE 5
ENGINE FULL LOAD PERFORMANCE (200-HOURS)

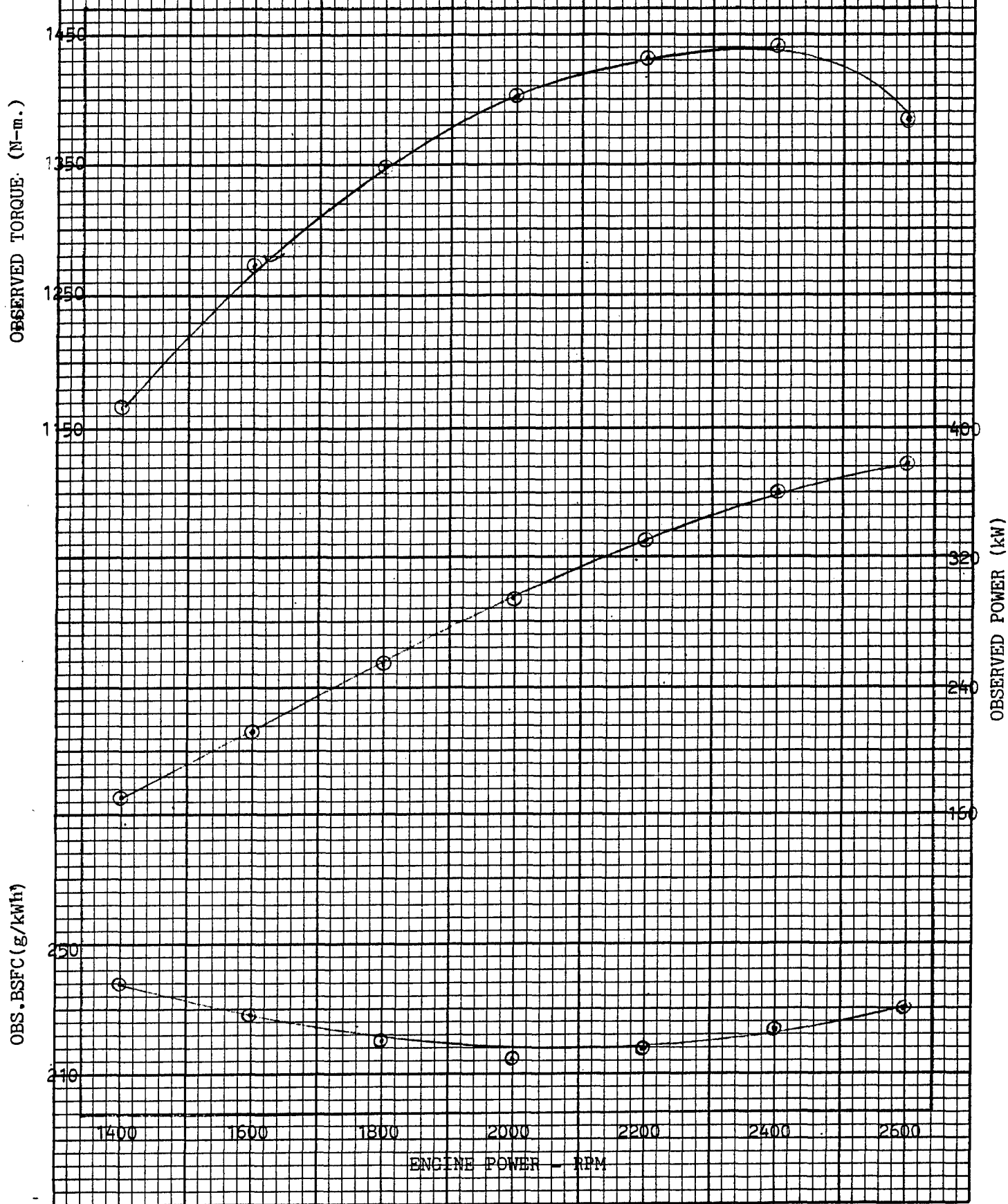
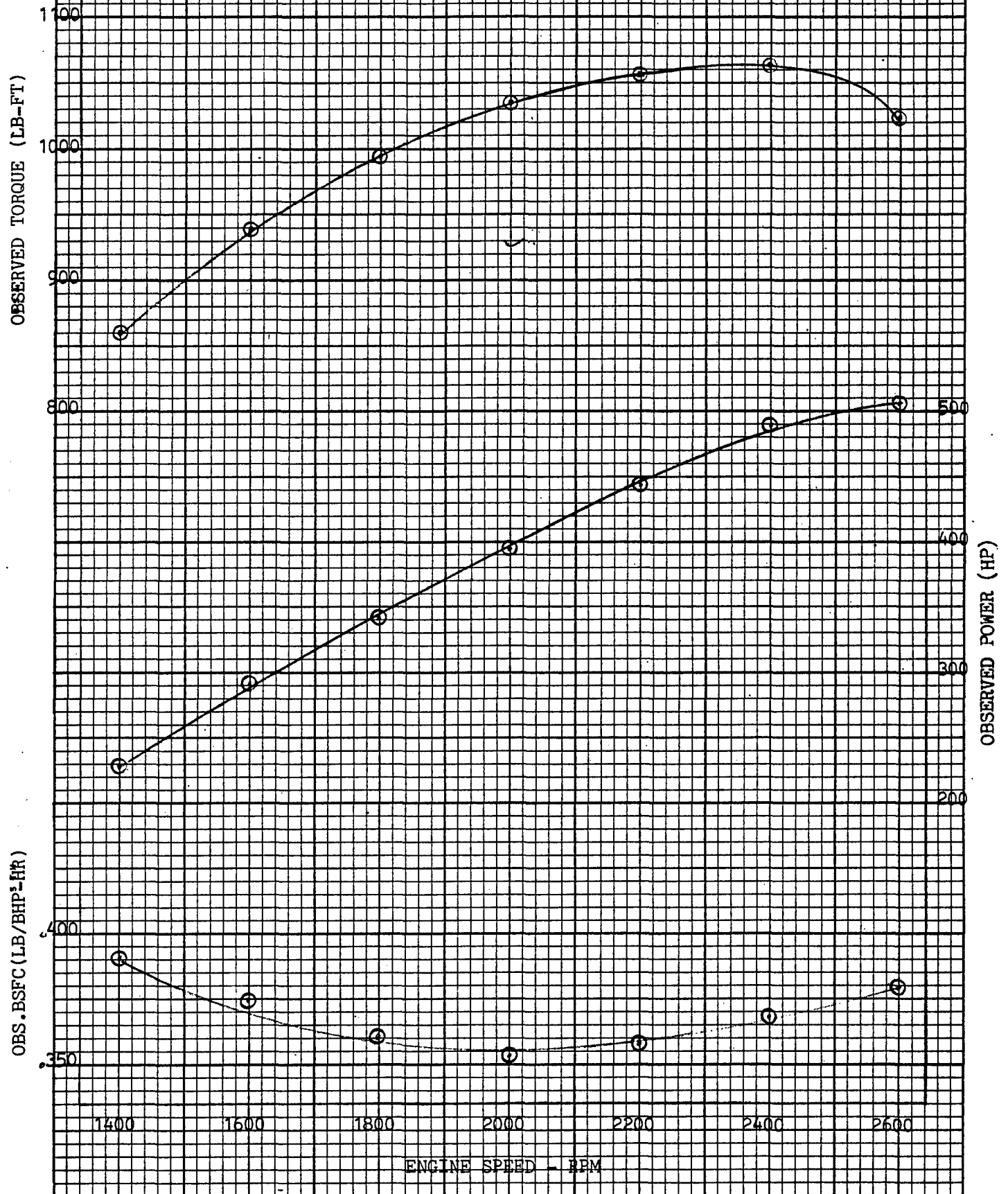


FIGURE 6
ENGINE FULL LOAD PERFORMANCE (200 HOURS)



Code E-436 Engine Full Load Performance Data

After 200 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP OF (°C)	AIR CLEANER OUTLET TEMP OF (°C)	FUEL TEMP TO ENGINE OF (°C)	ENGINE COOLANT OUTLET TEMP OF (°C)
2,600	1022 (1385.8)	505.9 (377.2)	191.88 (87.04)	0.379 (230.5)	257.9 (125.5)	69.6 (20.9)	83.6 (29.7)	200.7 (93.7)
2,400	1063 (1441.4)	483.5 (360.5)	177.98 (80.73)	0.368 (223.9)	257.1 (125.1)	71.5 (21.9)	83.0 (28.3)	202.0 (94.4)
2,200	1056 (1431.9)	442.3 (329.8)	158.30 (71.80)	0.358 (217.8)	254.9 (123.8)	73.8 (23.2)	81.4 (27.4)	201.6 (94.2)
2,000	1034 (1402.1)	393.8 (293.7)	138.98 (63.04)	0.353 (214.7)	252.4 (122.4)	74.8 (23.8)	82.2 (27.9)	201.4 (94.1)
1,800	994 (1347.8)	340.7 (254.1)	122.99 (55.79)	0.361 (219.6)	250.0 (121.1)	74.4 (23.6)	83.6 (28.7)	201.4 (94.1)
1,600	939 (1273.3)	286.1 (213.3)	106.98 (48.53)	0.374 (227.5)	247.7 (119.8)	76.3 (24.6)	82.9 (28.3)	201.4 (94.1)
1,400	861 (1167.5)	229.5 (171.1)	89.80 (40.73)	0.391 (237.8)	245.4 (118.6)	75.7 (24.3)	83.3 (28.5)	201.5 (94.2)

Applicable Test Conditions/Range Variations

Intake Air Restriction -5.5 to -1.3 in. H²O (96.7 to 97.7 kPa)
 Exhaust Gas Outlet Pressure 19.0 to .2 in. H²O (102.8 to 98.1 kPa)
 Dry Air Barometer: 29.43 -in. Hg (99.6 kPa)

TABLE 3

FIGURE 7
ENGINE FULL LOAD PERFORMANCE (360 HOURS)

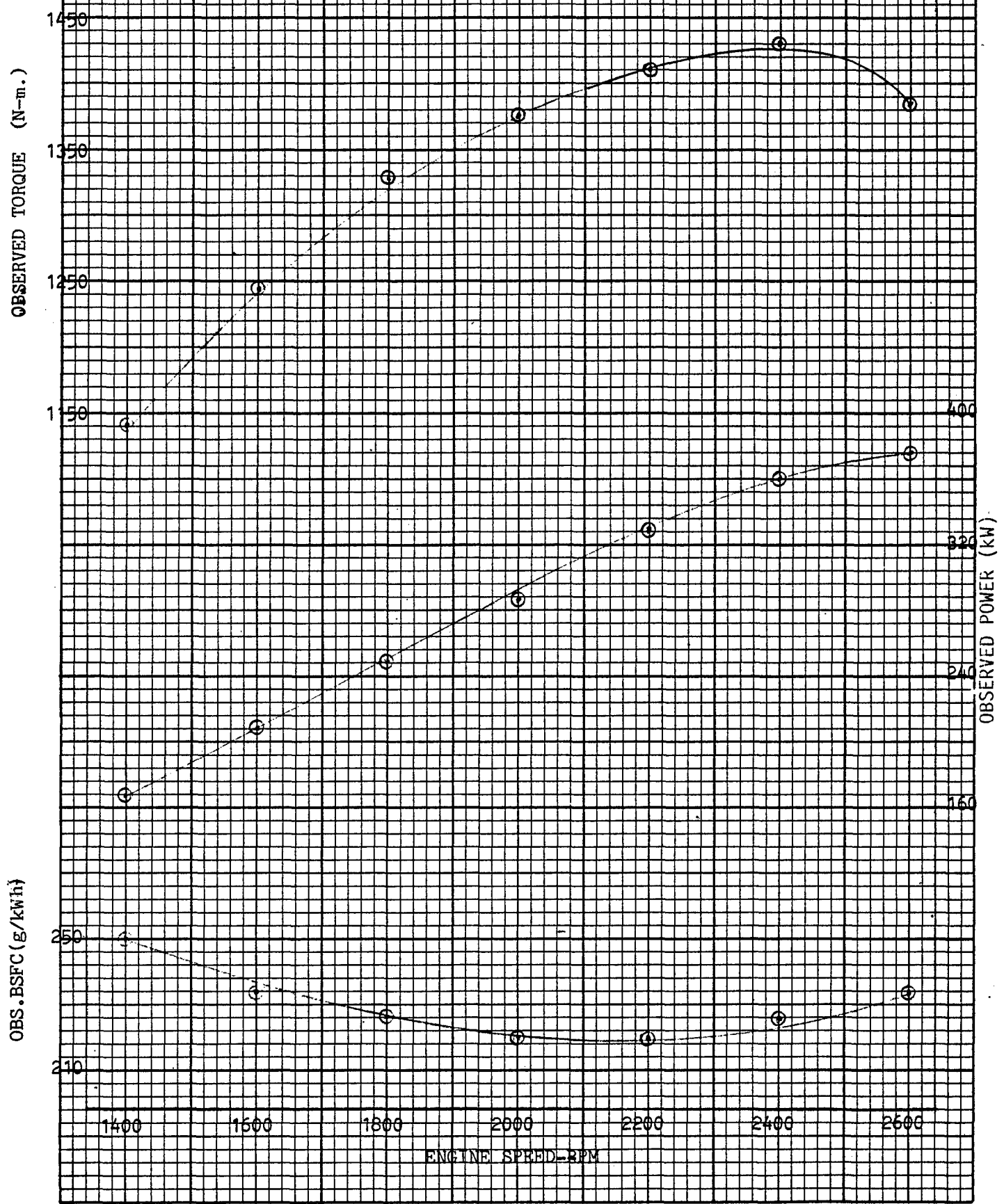
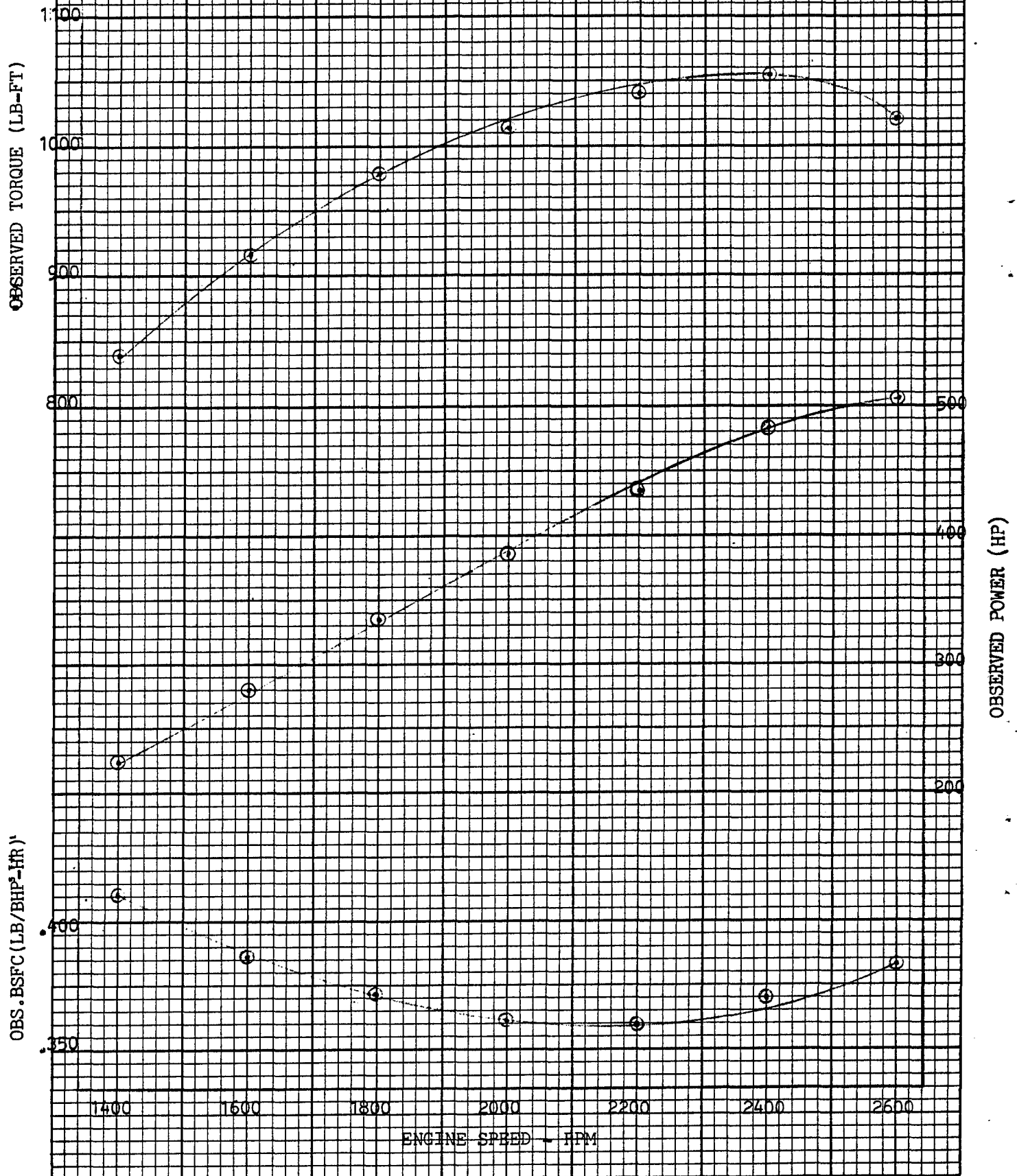


FIGURE 8
ENGINE FULL LOAD PERFORMANCE (300 HOURS)



Code E-436 Engine Full Load Performance Data

After 300 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP OF (°C)	AIR CLEANER OUTLET TEMP OF (°C)	FUEL TEMP TO ENGINE OF (°C)	ENGINE COOLANT OUTLET TEMP OF (°C)
2,600	1020 (1383.1)	505.0 (376.6)	193.45 (87.75)	0.383 (233.0)	257.2 (125.1)	80.8 (27.1)	85.5 (29.7)	199.6 (93.1)
2,400	1055 (1430.6)	482.1 (359.5)	178.77 (81.09)	0.371 (225.7)	255.1 (123.9)	79.9 (26.6)	84.9 (29.4)	198.8 (92.7)
2,200	1040 (1410.2)	435.6 (324.8)	157.01 (71.22)	0.360 (219.0)	251.2 (121.8)	78.4 (25.8)	83.3 (28.5)	198.7 (92.6)
2,000	1013 (1373.6)	385.7 (287.6)	139.74 (83.39)	0.362 (220.2)	247.9 (119.9)	71.6 (22.0)	81.5 (27.5)	198.5 (92.5)
1,800	997 (1327.5)	335.5 (250.2)	125.17 (56.78)	0.373 (226.9)	245.7 (118.7)	70.0 (21.1)	82.3 (27.9)	198.7 (92.6)
1,600	918 (1244.8)	279.7 (208.6)	108.00 (48.99)	0.386 (234.8)	243.6 (117.6)	70.0 (21.1)	81.0 (27.2)	198.7 (92.6)
1,400	840 (1139.0)	223.9 (167.0)	92.31 (41.87)	0.412 (250.6)	240.9 (116.1)	70.2 (21.2)	82.4 (28.0)	198.7 (92.6)

Applicable Test Conditions/Range Variations

Intake Air Restriction -6.1 to -1.4 in. H²O (96.6 to 97.7 kPa)
 Exhaust Gas Outlet Pressure 18.3 to .12 in. H₂O (102.6 to 98.1 kPa)
 Dry Air Barometer: 28.67 -in. Hg (97.1 kPa)

FIGURE 9
ENGINE FULL LOAD PERFORMANCE (400 HOURS)

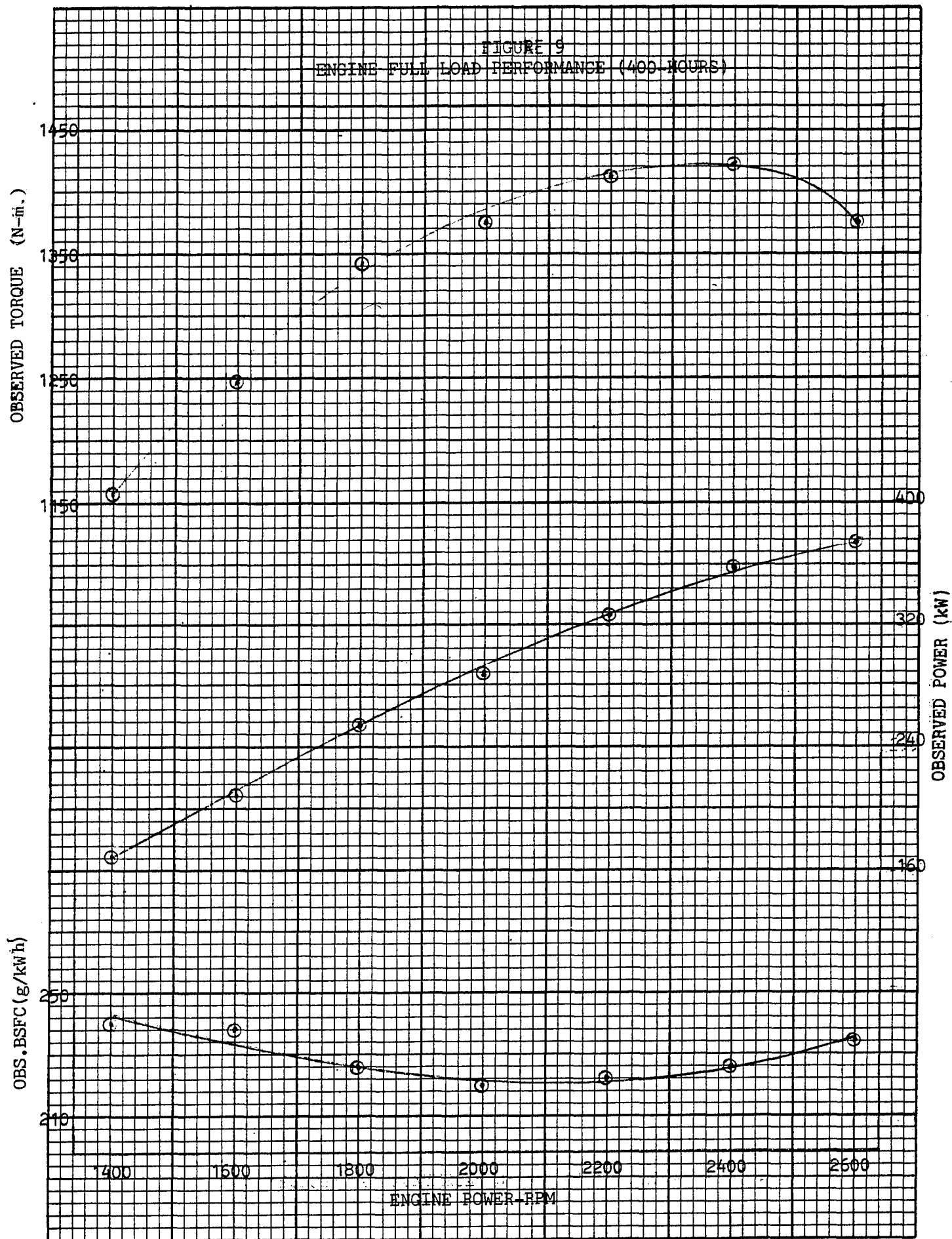
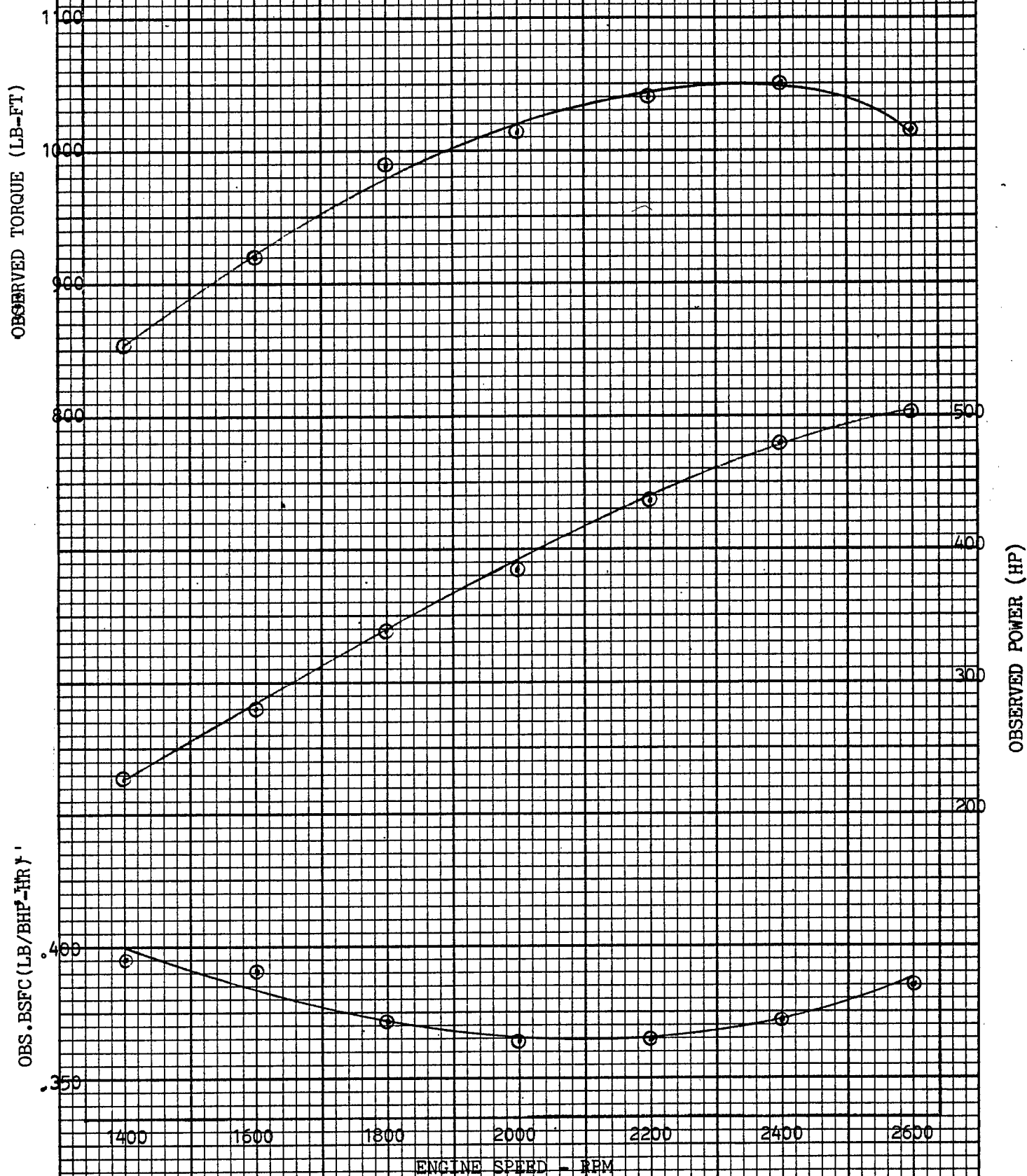


FIGURE 10
ENGINE FULL LOAD PERFORMANCE (400-HOURS)



Code E-436 Engine Full Load Performance Data

After 400 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP OF (°C)	AIR CLEANER OUTLET TEMP OF (°C)	FUEL TEMP TO ENGINE OF (°C)	ENGINE COOLANT OUTLET TEMP OF (°C)
2,600	1016 (1377.7)	503.0 (375.1)	193.71 (87.87)	0.395 (234.2)	259.1 (126.2)	79.5 (26.4)	87.3 (30.7)	201.1 (93.9)
2,400	1050 (1423.8)	479.8 (357.8)	178.66 (81.04)	0.372 (226.3)	256.6 (124.8)	78.6 (25.9)	87.9 (31.1)	201.3 (94.1)
2,200	1041 (1411.6)	436.1 (325.2)	159.18 (72.20)	0.365 (222.0)	253.3 (122.9)	77.5 (25.3)	85.7 (29.8)	201.4 (94.1)
2,000	1014 (1375.0)	386.1 (287.9)	140.43 (63.70)	0.364 (221.4)	250.2 (121.2)	77.5 (25.3)	85.6 (29.8)	201.3 (94.1)
1,800	990 (1342.4)	339.3 (253.0)	126.11 (57.20)	0.372 (226.3)	247.8 (119.9)	77.3 (25.2)	85.0 (29.4)	201.6 (94.2)
1,600	921 (1248.9)	280.6 (209.2)	109.70 (49.76)	0.391 (237.8)	244.6 (118.1)	77.2 (25.1)	84.0 (28.9)	201.5 (94.2)
1,400	853 (1156.7)	227.4 (169.6)	89.77 (40.72)	0.395 (240.3)	237.8 (114.3)	76.9 (24.9)	82.0 (27.8)	198.8 (92.7)

Applicable Test Conditions/Range Variations

Intake Air Restriction -5.8 to 1.3 in. H₂O (96.6 to 98.4 kPa)
Exhaust Gas Outlet Pressure 19 to .03 in. H₂O (102.8 to 98.1 kPa)
Dry Air Barometer: 28.96 -in. Hg (98.1 kPa)

Oil Consumption During Endurance

<u>Engine Test Hours</u>	<u>Quantity Oil Added (lb)</u>	<u>Cumulative Consumption (lb)</u>
0	0	SUMP FULL
7.5	3.6	3.6
14.0	1.8	5.4
27.5	1.8	7.2
40.0	1.8	9.0
47.5	1.8	10.8
54.0	3.6	14.4
60.5	1.8	16.2
80.5	1.8	18.0
87.5	1.8	19.8
100.	0	19.8
140.5	1.8	21.6
154.0	2.1	23.7
160.0	1.8	25.5
174.0	2.5	28.0
187.0	1.8	29.8
200.0	0	29.8
230.0	3.6	33.4
260.0	1.4	34.8
287.0	2.0	36.8
300.0	0	36.8
307.0	1.5	38.3
314.0	1	39.3
334.0	1.9	41.2
354.0	.5	41.7
370.0	1.2	42.9
380.0	.5	43.4
400.	0	43.4

TABLE 6

FIGURE 11
FULL LOAD HEAT REJECTION

SPECIFIC HEAT. REJECTION W/W

TOTAL HEAT REJECTION (kW)

OBSERVED POWER (kW)

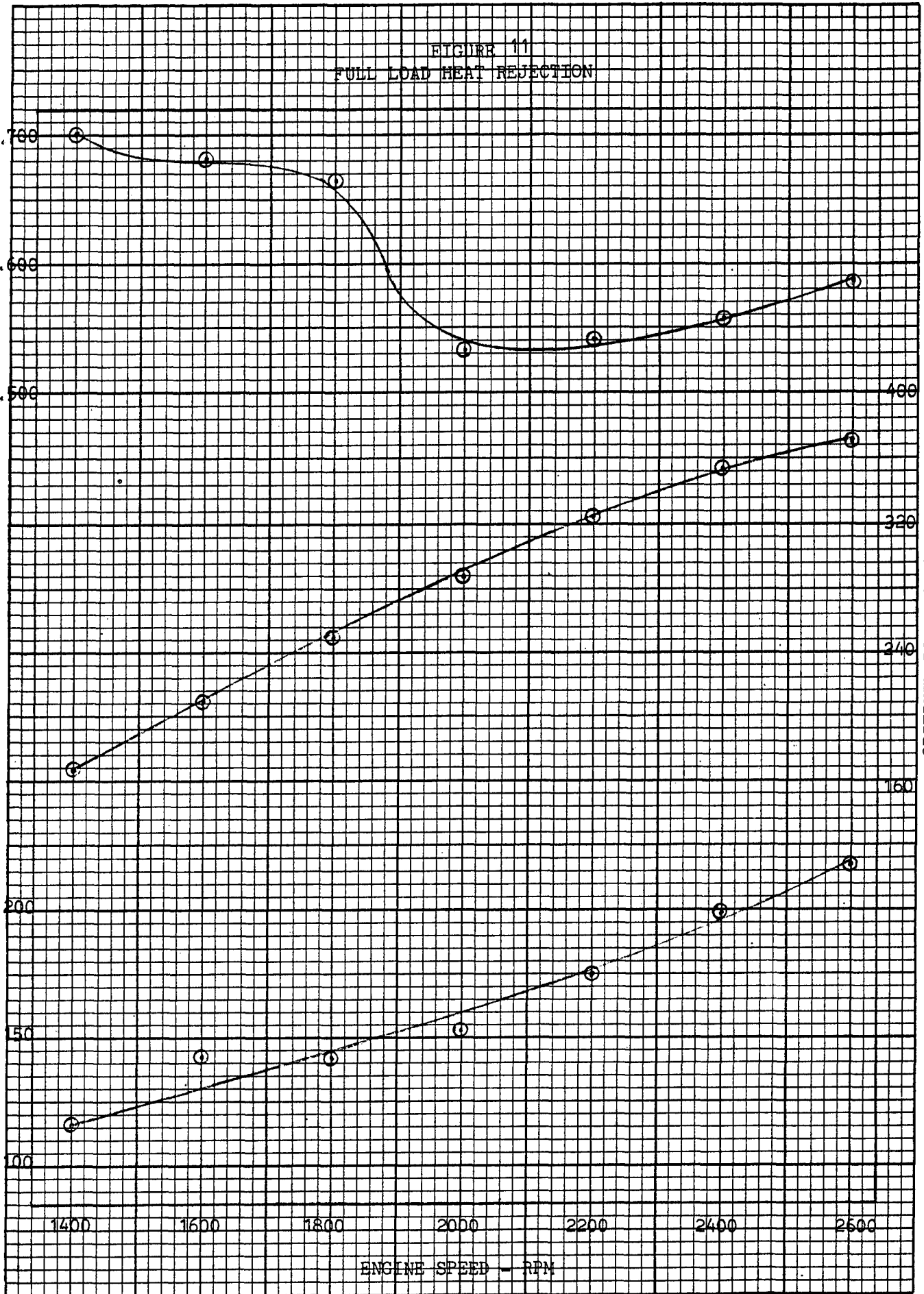
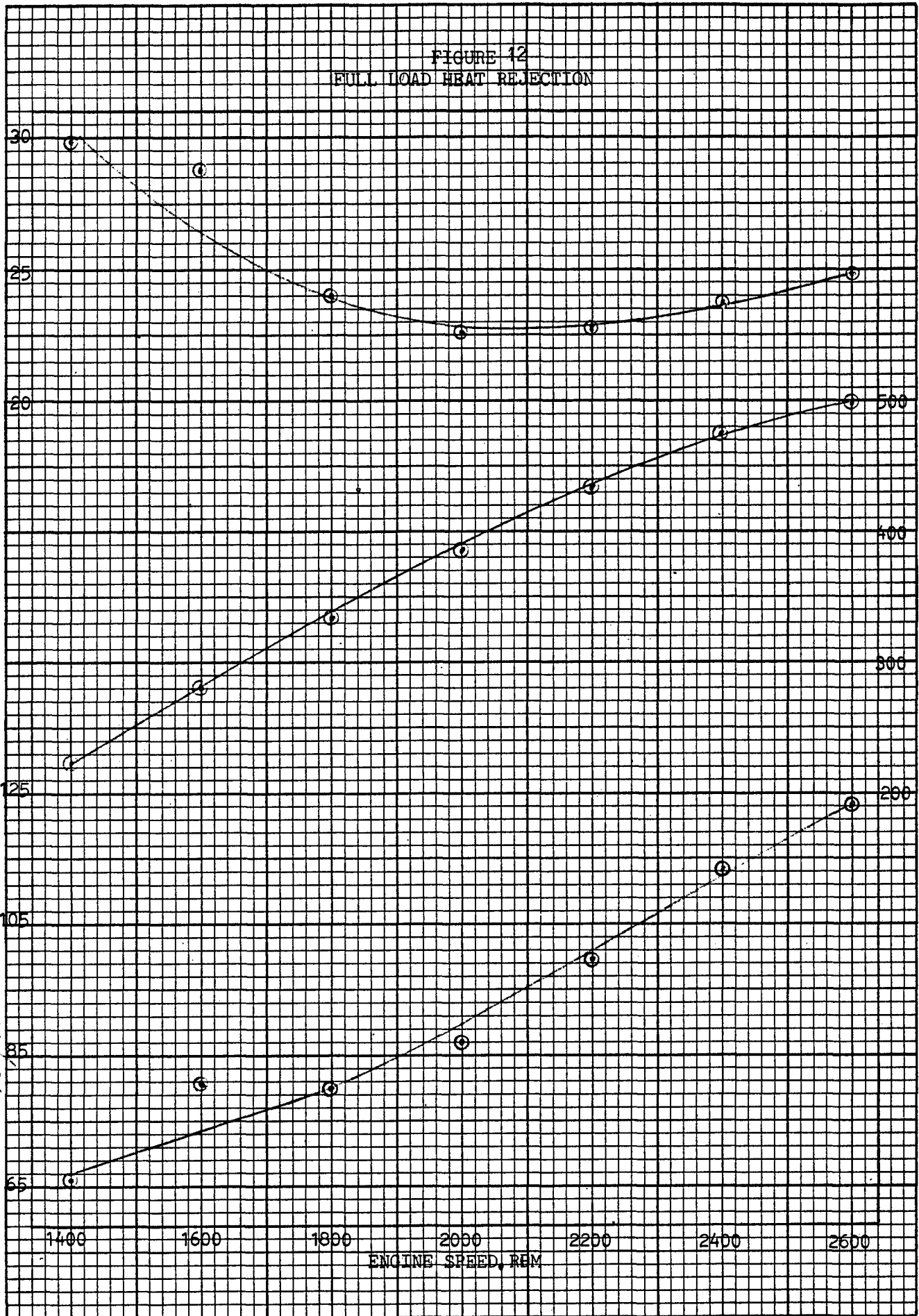


FIGURE 12
FULL LOAD HEAT REJECTION

SPECIFIC HEAT REJECTION
(BTU/BHP-MIN)

TOTAL HEAT REJECTION
BTU/MIN $\times 10^2$

OBSERVED POWER (HP)



FULL POWER INLET AIR FLOW

NOTE: (These values not from engine tested but from an engine of the same model and are submitted as general information)

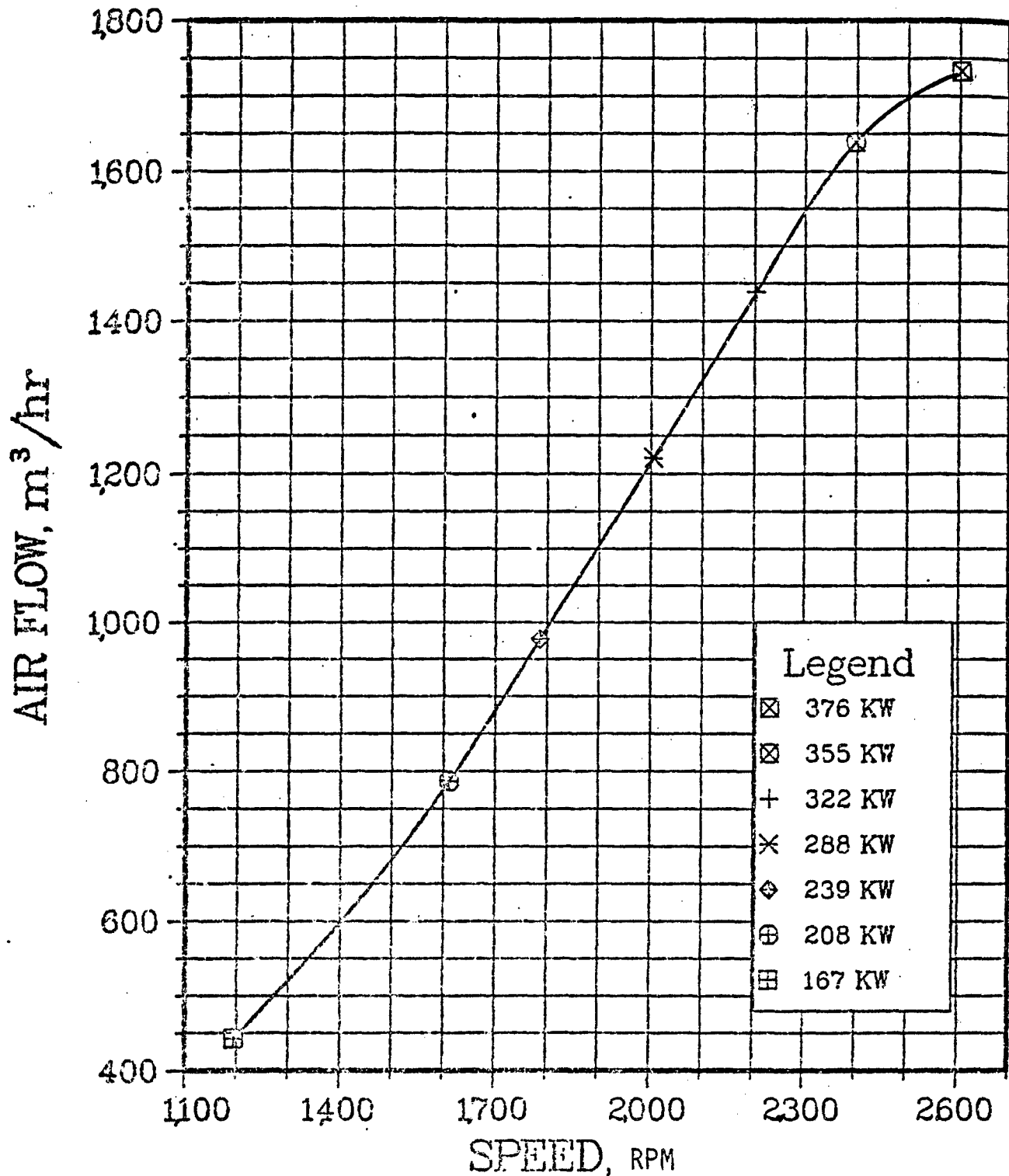


Figure 13 FULL POWER INLET AIR FLOW

AIR FLOW UNITS. STANDARD CUBIC METRES PER HOUR

NOTE: (These values not from engine tested but from an engine of the same model and are submitted as general information)

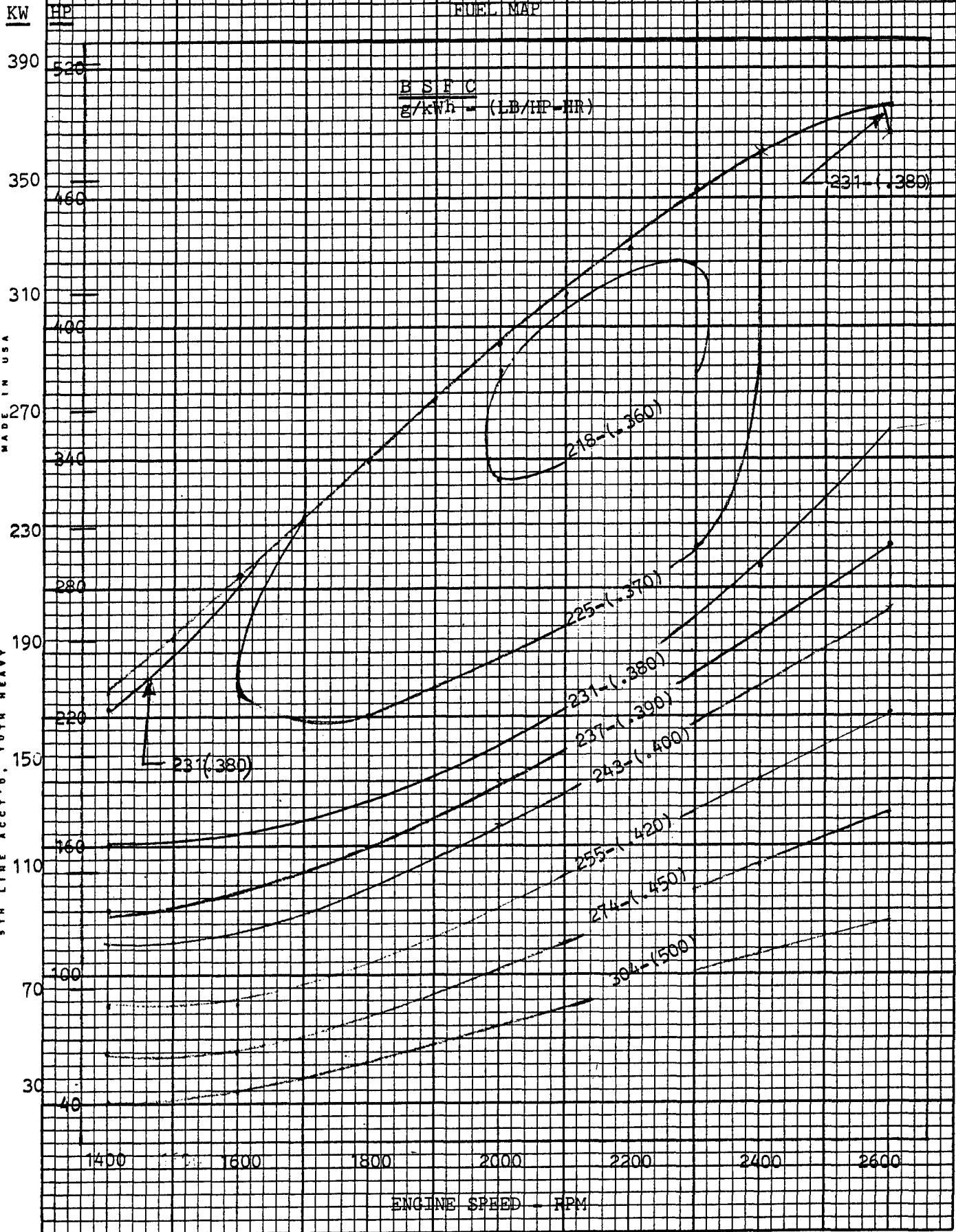
SPEED RPM	ENDURANCE HOURS		
	0 HOURS	100 HOURS	200 HOURS
2,600	1.4	1.85	1.65
2,400	1.05	1.5	1.35
2,200	1.1	1.45	1.55
2,000	1.35	2.0	1.8
1,800	3.25	3.8	3.8
1,600	3.25	3.8	3.8

TABLE 7. BOSCH SMOKE READINGS

DRAWING PAPER NO. 1280-10-3
 TRACING POWER NO. 1227-10-8
 CROSS SECTION-10X10 TO 1 INCH
 5TH LINE ACCT'D, 10TH HEAVY

MADE IN USA

FIGURE 11
 FUEL MAP



APPENDIX A - TEST PROGRAM

PROPULSION SYSTEMS DIVISION
TEST PROGRAM CODE E-436 ENGINE
(Cell #6)

TITLE: MACI Evaluation of the Code E-436 Engine

PURPOSE:

To determine the military adaptability and performance characteristics of Code E-436 Commercial Diesel Engine.

OUTLINE OF TESTS:

1. Prepare Code E-436 engine for performance and endurance tests.
2. Install instrumentation.
3. Calibration of instrumentation and equipment.
4. Engine operating limits, adjustments and instrumentation checkout.
5. Engine instrumentation and full load operational check-out.
6. Full load performance.
7. Part load performance.
8. Full load heat rejection.
9. Four hundred hour NATO endurance test.
10. Disassembly, visual inspection and components measurement of engine (may be conducted in-house and/or contractor's facility).
11. Evaluation of results and final report.

TEST MATERIAL:

1. Engine Code E-436

Type	90° VEE, 500 HP @ 2600 rpm
Number of cylinders	8
Bore and stroke, in.	5.50 x 4.75
Displacement - cu. in.	903
Method of operation	4 cycle turbocharged, after cooled compression ignition
Compression ratio	15.5 to 1

2. Lubricating oil - Referee, grade 30, conforming to Military Specification MIL-L-2104C.

3. Fuel - Federal Specification MIL-F-46162B (high sulfur).

TEST EQUIPMENT:

Test Cell No 6, dynamometer, controls, associated instrumentation and equipment, Bldg. 212.

TEST PROCEDURES:

1. Prepare engine for performance tests.

a. Install engine in test cell and make connections to dynamometer. Obtain dry weight of engine and record. Make necessary fuel, exhaust, and intake air connections. Install cooling tower and fuel throttle and shutdown connection. Make provisions for smoke readings and measuring air flow.

b. Install all required thermocouples, pressure lines, speed and load cell connections. Install warning/shutdown lights for critical temperature/pressure and RPM limits on engine and dynamometer equipment.

c. During heat rejection tests, normal type cooling tower will be installed. Thermostat is required to be blocked in open position during test to assure accurate results. An engine thermostat (180° F) will be used. The cooling tower will be adjusted to maintain 205° F $\pm$ 5° engine out temperature.

d. Engine blow-by and/or crankcase pressure will be closely monitored during full power performance run to assure adequate engine operation. In addition engine oil temperature and pressure will be closely monitored.

e. Cooling tower will utilize a sight glass in the lower pipe (engine filled with a 50/50 water and antifreeze mixture. A 15 psi pressure cap will be used and shop air, through a regulator, will supply approximately 12 psi pressure to the cooling system.

2. Instrumentation - Install instrumentation to obtain and record data at each specified speed.

a. <u>Temperature, °F</u>	<u>Range</u>	<u>Accuracy</u>
(1) Air, cell ambient (I&R)	60-120	± 2
(2) Air entrance to air meter	60-120	± 2
(3) Air turbo inlet after air cleaner	60-120	± 2
(4) Air, turbo outlet (to aftercooler, 120-500 R&L)		± 2
(5) Exhaust, after turbo	200-1200	±10
(6) Exhaust, before turbo (I&R)	200-1400	±10
(7) Exhaust, ports (8)	200-1500	±10
(8) Oil sump	120-300	± 2
(9) Fuel, before transfer pump	60-120	± 2
(10) Fuel Spill	60-160	± 2
(11) Coolant, engine inlet **	120-250	± 2
(12) Coolant, engine outlet **	120-250	± 2
(13) Combustion air at meter (Meriam flow meter)	30-160	± 2
(14) Cooling water, tower inlet *	35-100	
(15) Cooling water, tower outlet *	35-250	
(16) Engine oil gallery (manifold)	60-270-	
(17) Instrumentation bath	200	± 2

* Indicates Quartz Temperature Probes

** Indicates Quartz Temperature Probes in addition to regular thermocouple

b. <u>Pressures, Gauge</u>	<u>Range</u>	<u>Accuracy</u>
(1) Air, Test cell (in. H ₂ O)	0 to -1	±.1
(2) Air, before turbo (in. H ₂ O)-S	0 to -25	± 1
(3) Air, after turbo (in. hg)	0 to +60	±.2
(4) Air across Meriam flow meter (in. H ₂ O)	0 to -28	±.1
(5) Air at Meriam flow meter center (in. H ₂ O)	0 to -20	±.05
(6) Air crankcase (in. H ₂ O)	-5 to +5	±.1
(7) Exhaust, before turbo (in. hg) Left & Right	0 to +60	±.5
(8) Exhaust, outlet (in. H ₂ O)-S	0 to +50	--
(9) Fuel supply before transfer pump (psi) at primary filter	0 to -5	±.1
(10) Fuel supply after transfer pump (psi) at secondary filter	0 to +70	± 1
(11) Engine oil gallery (psi)	0 to +100	± 2
(12) Coolant pump outlet (psi)	0 to +50	± 2
(13) Coolant pump inlet (psi)	0 to +25	± 1
c. <u>Miscellaneous</u>		
(1) Engine speed, (RPM)	0 - 3000	± 5
(2) Dynamometer load, (ft-lb)	0 - 2000	± 1
(3) Fuel flow (lb/hr)	200	±.1
(4) Blowby (CFM)	0 - 10	±.2
(5) Smoke Density, Bosch meter	--	--

d. Special Instruction Considerations

- (1) Dymec data acquisition system to be used for data gathering.
- (2) Quartz Thermometers to be used for heat rejection test.
- (3) Load cell to be used for measuring torque.
- (4) Digital Cox fuel weigh system to be used for measuring fuel consumption.
- (5) Cooling water weigh system 0-200 lbs.
- (6) Smoke density, Bosch system.
- (7) Blowby meter for measuring engine blowby.
- (8) Temperature reference bath (Maintain at 200° F).
- (9) Meriam air flow meter.

e. The following monitors will be provided for operator use:

<u>Temperature</u>	<u>Pressure</u>
(1) Ambient air (I&R)	(1) Oil Gallery
(2) Air after turbo	(2) Air after turbo
(3) Oil gallery	(3) Fuel after pump
(4) Fuel before pump	(4) Exhaust back pressure
(5) Engine coolant in	
(6) Engine coolant out	

3. Calibration of instrumentation and equipment.

All instrumentation and equipment will be calibrated prior to start of test and at ranges specified in the previous paragraph 2.

4. Engine operating limits and adjustments.

a./ Observe the following engine operating limits and test conditions for performance and endurance tests.

(1) Oil Gallery temperature, 250° F warning, 260° F manual return to idle and contact test engineer.

(2) Oil pressure idle 15 PSI warning, 10 PSI shutdown. Oil pressure normal operation 45 to 65 PSI above 1000 RPM, 30 PSI shutdown.

(3) Air cell Ambient as close as possible to 77° F.

(4) Coolant outlet temperature 205 ± 5° F, warning 210° F, manual return to idle at 215° F. Cooling system will be pressurized to 12 PSI.

(5) Fuel temperature before pump: 85 ± 5° F.

(6) Exhaust outlet pressure at rated conditions 16 in. H₂O ± 3.

(7) Crankcase pressure maximum 5 in. H₂O.

(8) Nominal fuel flow 200 lb/hr at 2600 RPM.

(9) Exhaust temperature into turbo, 1080° F maximum.

b./ Maintain and record the following adjustments at completion of each 100 hour interval of endurance test or as indicated. Contact test engineer prior to any adjustment.

(1) Idle speed 650 RPM.

(2) Governed speed (no load) 2960 RPM.

(3) Max torque 1030 ft-lb @ 1900 RPM.

(4) Full load 2600 RPM.

5. Engine Instrumentation and Full Load Operational Check-Out.

a. Engine will be run to check leaks, instrumentation, recording and printout systems. The following temperatures and pressures will be maintained:

- (1) Inlet air (maintain as close as possible to 77° F)
- (2) Air pressure at turbocharger inlet at rated conditions, -5 ± 1 in. H_2O .
- (3) Exhaust pressure at turbo outlet at rated conditions, 16 ± 3 in. H_2O .
- (4) Coolant outlet temperature $205 \pm 5^{\circ}$ F
- (5) Fuel temperature before pump $85 \pm 5^{\circ}$ F

Speeds will be verified after break-in.

b. Full load operational check will be conducted according to the following schedule. During break-in monitor blowby in CFM and/or pressure. Do not continue test if blowby exceeds allowed maximum. Take complete data and record on log sheet for each break-in period. Repeat the cycle down and up.*

<u>Period No.</u>	<u>Time, Minutes</u>	<u>Engine, RPM</u>	<u>Observed BHP</u>
1	10	650 (Idle)	--
2	10	1200	50 217
3	10	1400	100 375
4	10	1600	150 493
5	10	1700	200 513
6	10	1900	250 691
7	20	2100	300 150
8	20	2200	350 226
9	20	2400	400 375
10	20	2500	450 945
11	20	2600	500 1010
12	20	--	--

* Repeat this cycle in a reverse order using same RPM and power values.

c. During period 5 or following period 7, check governor and notify test engineer prior to making adjustments, to limit the maximum speeds as follows:

Full load	2600 RPM
No load (Governed Speed)	2960 RPM

e. During period No.11 the following limits must prevail..

- | | |
|---|---|
| (1) Oil gallery pressure | 30 to 55 PSI |
| (2) Exhaust temperature into turbo | 1080° F max. |
| (3) Crankcase pressure (in. H ₂ O) | 5 |
| (4) Power output at rated | 500 ± 3% at 85°F air inlet,
29.38 in. HG Barometer dry |

6. Performance Test (Nominal 500 BHP)

Conduct performance tests with full rack, under the conditions listed in paragraph 4. Record all data listed under instrumentation for engine speeds of 1400 RPM to 2600 RPM at 200 RPM increments. At each setting the engine should be run for a sufficient time for stabilization. Additional tests (part load performance and heat rejection) will be conducted at completion of durability test.

7. Part Load Performance Test (Nominal 500 BHP)

Conduct part load performance tests at 85, 70, 60, 50, 40, 25 and 15 percent loads using speeds of 1400 RPM to 2600 RPM in 100 RPM increments. Paragraph 5 conditions will be maintained during runs. One hundred percent loads will be determined just prior to part load testing. Perform an idle fuel consumption test run with complete printout at the end of part load performance tests.

8. Heat Rejection Tests(Perform at Completion of Durability Test)

Determine heat rejection at full load, 205 ± 5° F, engine coolant out temperature at the following speeds; 1400 RPM to 2600 RPM in 200 RPM increments. Remaining conditions as specified in paragraph 4. (Engine operating limits and adjustments).

9. Four Hundred (400) Hour NATO Endurance Test

a. The 400 hour NATO endurance will be divided into four periods of 100 hours each. Each 100 hour period is to consist of ten (10), ten hour periods as shown in test schedule A. (New NATO cycle).

TEST SCHEDULE A

<u>Period</u>	<u>Percent Rated Speed</u>	<u>Percent Load</u>	<u>(LB/FT)</u>	<u>Time Hours</u>
1	Idle (650 RPM)	0		1/2
2	100 (2600 RPM)	100	(1010)	2
3	Governed Speed (2960 RPM)	0		1/2
4	75 (1950 RPM)	100		1
5	Idle ↔ 100	0 ↔ 100		
		4 Min. 6 Min.		2
6	60 (1560 RPM)	100		1/2
7	Idle (650 RPM)	0		1/2
8	Governed Speed (2960 RPM)	70	(707)	1/2
9	Max Torque Speed (1900 RPM)	100		2
10	60 (1560 RPM)	50	(505)	1/2
TOTAL DURATION				10

Conduct 400 hour NATO endurance test according to Test Schedule A. Values of speeds and torques to be provided by test engineer following completion of performance test.

b. During 400 hour endurance, the following pressures and temperatures will be regulated to the values as indicated.

(1) Pressures

- (a) Air pressure at turbocharger inlet shall be set -5 ± 1 (in. H₂O) at rated conditions and restriction held throughout other tests.
- (b) Exhaust outlet pressure at full power through speed range, 13-19 inches H₂O: at idle and part load, 0-13 inches of H₂O.

(2) Temperatures

- (a) Inlet air to turbocharger as close as possible to 77° F.
- (b) Coolant outlet temperature $205 \pm 5^\circ$ F.
- (c) Fuel before secondary filter $85 \pm 5^\circ$ F.

c. Take four ounce oil sample before starting endurance and every 100 hours thereafter, take two ounce oil sample at 25 hour intervals. (Purge oil sample line and take sample from oil gallery with engine idling). Replace the removed sample oil with same amount and type new one.

d. Check engine oil at completion of every five hour test period or before engine is started for a new day of test (whichever occurs first). Allow time for oil to settle before reaching full mark. Do not overfill.

e. Data will be recorded during the last five minutes of each of the ten periods listed in Test Schedule A, and just before stopping engine.

f. The following maintenance and adjustments to engine will be conducted after each 100 hour test period, and before power check. Check with test engineer.

(1) Change oil

(2) Replace oil and fuel filters

(3) Record oil added (less sample) to bring to required level

(4) Maintain adjustments as indicated on page A-5.

(5) Visually inspect engine for leaks, breaks, etc.

g. The 100 hour power check tests shall be conducted under temperature and pressure conditions listed. Record all data listed under "Instrumentation" for engine speeds from 1400 RPM to 2600 RPM in 200 RPM increments, up only. At each setting, the engine should be run for a sufficient time for stabilization. In addition, smoke density samples will be taken at each speed setting.

10. Obtain photographs of engine test set up.

11. Disassembly and Visual Inspection of Engine. Record breaking torques of cylinder head, crankshaft, and connecting rod bolts and photograph parts if required during disassembly. Make components wear measurement.

12. Evaluation of Results and Report.

a. Consolidate and evaluate data.

b. Prepare report.

c. Obtain photographs of set up and engine parts as required.

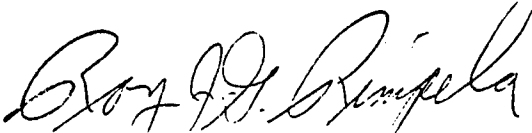
JOB ASSIGNMENTS:

1. DRSTA-TB will be responsible for gathering data, maintaining a daily log book, and test data log, directing personnel and general execution of test.
2. DRSTA-RGES will be responsible for day to day technical decisions, monitoring test, evaluation of data, and preparing a report.
3. Any changes in the above test program shall be mutually agreed upon by DRSTA-TB and DRSTA-RGES and confirmed by a supplement to this basic test program. Each supplement will be evaluated for potential cost and for schedule revisions.

WRITTEN BY: .

 16 Nov '82
F. Rostam-Abadi Ext 48537
Project/Test Engineer

REVIEWED AND APPROVED BY:


Roy J. G. Rimpela Ext 48528
Team Leader/Engine Testing

APPENDIX B - FUEL ANALYSIS

ANALYSES OF REFEREE GRADE DIESEL FUEL
(MIL-F-46162B) SAMPLES

<u>Properties</u>	<u>Requirements</u>	<u>#6 Tank AL-12077-F</u>
Density, kg/L at 15°C	Report	0.8655
Gravity, °API	NR (1)	31.9
Distillation, °F (°C)		
Initial boiling point	Report	380 (193)
10% recovered	Report	446 (230)
50% recovered	473-545 (245-285)	514 (268)
90% recovered	626-675 (330-357)	616 (324)
95% recovered	662-707 (350-375)	646 (341)
End point, max	725 (385) max	678 (359)
Sulfur, wt%	0.95-1.05	1.05
Accelerated stability,		
total insolubles, mg/100 mL	1.5 max	1.4
Cetane number	40-45	54
Cetane index	40-45	42
Kinematic viscosity at		
40°C, cSt	1.9-4.1	--
Cloud point, °C	-13 max	--
Particulate contamination,		
mg/L (0.8µm filter)	10 max	2.5
Volume filtered, L	1	1

(1) NR = No requirement

(2) -- = Not measured

APPENDIX C - SAMPLE DATA SHEET

TAPE NO 136		U S ARMY TANK AUTOMOTIVE COMMAND		TEST ENGINEER R RIMPELA	
TEST CELL NO 6		RESEARCH AND DEVELOPMENT COMMAND		TEST OBSERVER	
OBJECT OF TEST		ENGINE SERIAL NO 11053470		S O W	
100% POWER CURVE		ENGINE CODE NO E-135		S O W	
		FUEL MIL-F-46162B (1% SULFUR) OIL MIL-L-2104C (SAE 30 IMPERIAL OIL)		S O W	
START		1245		1430	
DATE		17 MAY 1983		1445	
TIME		2		6	
READING NO		2		7	
PERIOD NO		3		5	
TOTAL TEST HOURS		200.00		200.00	
TOTAL ENGINE HOURS		332.30		334.30	
OBSERVED BAROMETER		(HG) 1.356 IN		1441.4	
TEMP CORRECTION		29.73		1385.8	
CORRECTED BAROMETER		29.62		377.2	
VAPOR PRESSURE		19		228.9	
DRY AIR BAROMETER		29.43		230.5	
WET BULB TEMP		52		219.8	
DRY BULB TEMP		70			
INDICATED ENGINE RPM		FR		FR	
ACTUAL ENGINE RPM		2600		2200	
DYNAMOMETER LOAD (LB FT)		1022		1050	
OBSERVED HP		505.4		442.3	
CORRECTED HP					
OBSERVED TORQUE					
CORRECTED TORQUE					
FUEL WEIGHT INCREMENT (LB)		30.1		SEC READINGS	
TIME (SEC)		3		MIN AVERAGE	
CAL FUEL CONS (LBS PER HOUR)		191.883		177.984	
FUEL CONS (LBS BHP HR)		.379		.368	
TOTAL FUEL CONS (GALS)					
ENGINE OIL ADDED (LBS)		OIL CHANGE			
REFERENCE BATH TEMP (F)		200		200	
QUARTZ T1 WATER TOWER INLET TEMP (F)					
QUARTZ T2 WATER TOWER OUTLET TEMP (F)					
QUARTZ T2-T1 DIFF (F)					
QUARTZ T1 ENGINE COOLANT INLET (F)					
QUARTZ T2 ENGINE COOLANT OUTLET (F)					
QUARTZ T2-T1 DIFF (F)					
BOSCH SMOKE READING					
BLOWBY (CFM)					
CRANKCASE PB MANOMETER (H2O)					
HEAT REJECTION DATA (LBS)					
COOLING WATER (SEC)					
TIME (SEC)					

[illegible]

APPENDIX D - NATO ENGINE TEST SPECIFICATIONS

NATO STANDARD ENGINE LABORATORY TEST

(GAS TURBINES ENGINES)

AEP-5

EDITION JUNE 80

NATO UNCLASSIFIED

D-2

CHAPTER 1

PURPOSE AND APPLICABILITY

SECTION 1-1. PURPOSE

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyse the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follows: "Power rating. . .Kw (. . .metric HP) at. . .RPM, in accordance with NATO code AEP 5. Edition June 1980."

SECTION 1-2. APPLICABILITY

These test conditions apply to all service vehicle (combat and transport) propulsion gas turbine engines with free power turbines.

NOTE : SI units will be used.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception.

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

- NOTES :
- (1) Engine measurements may be carried out before running-in.
 - (2) The manufacturer is responsible for defining the running-in programme, and the engine should have been run-in before it is submitted for testing.

- (3) In so far as possible, the manufacturer's drawings and technical data will be supplied with the engine, to assist inspection and measurement of components.
- (4) It is normal practice for the engine to be given a preliminary performance test immediately after receipt, to check acceptability.
- (5) The initial, if accomplished, and final inspection of the engine should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

- a - Main values**
 - Speed
 - Torque (engine output shaft)
- b - Ambient conditions**
 - Temperature of ambient air
 - Atmospheric pressure
 - Humidity
- c - Air and gases**
 - Inlet air temperature
 - Inlet depression
 - Inlet air flow (performance test only)
 - Exhaust temperature
 - Exhaust back pressure
 - Gas temperatures at points influencing fuel control (if required)
- d - Lubrication and cooling**
 - Oil temperatures and pressures
 - Temperatures into and out of external coolers
 - Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations)
 - Oil consumption (during endurance tests only)
- e - Fuel**
 - Fuel temperature
 - Fuel consumption
- f - Miscellaneous**
 - Smoke density
 - Other parameters which influence fuel control
 - Vibration

2.1.3. Regulated parameters

- Inlet Air Depression * at rated power :
 $25 \pm 2,5 \text{ mbar}$
- Exhaust Back Pressure at rated power :
 $20 \pm 2,5 \text{ mbar}$
- Fuel Temperature at Fuel Pump Inlet :
 $30^{\circ} \text{ C} \pm 3^{\circ} \text{ C}$
- Inlet Air Temperature :
 See Section III

* Depression differential between static atmospheric air pressure and the total pressure at the point of measurement.

2.1.4. TEST CONDITIONS

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than $\pm 1\%$ or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and fuel consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange (s) of the exhaust manifold (s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be taken preferably in the lubrication system. The measuring point will be specified in the test report.

Fuel temperature must be read at the fuel pump inlet.

Auxiliary power take-offs may be loaded and measured if desired.

2.1.5. MEASUREMENT ACCURACY

- TORQUE

The torque must be accurate within $\pm 0,5\%$ of the highest value recorded.

- OUTPUT SPEED

Measurement must be accurate to within $\pm 0,5\%$.

- FUEL CONSUMPTION

$\pm 1\%$ for all apparatus used.

- TEMPERATURES

Intake air $\pm 1^{\circ}\text{C}$.

- PRESSURE

Atmospheric pressure $\pm 0,7$ mbar

Air and gas pressure ± 50 mbar

Induction and exhaust pressure and depression $\pm 0,250$ mbar

Pressure of other fluids ± 250 mbar

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at Annex A).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, one of these settings being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speeds as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the Robert BOSCH Scale shall not exceed 4.5.

No correction factor will be applied and the test results must include air temperature and atmospheric pressure.

The inlet temperature shall be maintained as close as possible to 25°C .

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

During the endurance test, the inlet temperature will be kept as near as possible to 25°C or, when this is not practical, prevailing ambient.

- 2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.
- 2.4.3. Engine oil and filters may be changed after each 100 hour period.
- 2.4.4. The four 100 hour periods which make-up the endurance test are to be carried out with the fuel and lubricant defined in Chapter 3.
- 2.4.5. Each 100 hour period is to comprise ten 10 hour cycles. Each 10 hour cycle will be carried out in accordance with the programme (section 2.5).
- 2.4.6. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10-hour cycle, with the exception of sub-cycles 3, 4, 7, 8, 10, 11.
- 2.4.7. No interruptions are permitted during any of the sub-cycles, but the engine may be switched off on completion of any sub-cycle.
- 2.4.8. One-hundred percent power (load) will be governed by maximum fuel control setting, not adjusted to published maximum power.

SECTION 2-5 - PROGRAMME OF 10 HOUR CYCLE

Périod	Rated Speed %	Rated Load %	Duration (hours)
1	Idle (1)	Idle (1)	0,5
2	100	100	1
3	50 $\longleftrightarrow$ 100 3 min 3 min	100	1
4	Stop		0,25
5	70	100	1
6	Idle	Idle	0,5
7	Idle $\longleftrightarrow$ 100 2 min 3 min	Idle $\longleftrightarrow$ 100	2
8	Stop		0,25
9	100	100	1
10	Stop		0,25
11	Idle $\longleftrightarrow$ 100 2 min 3 min	Idle $\longleftrightarrow$ 100	2
12	Idle	Idle	0,25
Total			10

At least 5 times during each 100 hour period, the engine will be shut down for a minimum of 8 hours.

(1) Manufacturer's published idle or as specified by vehicle installation.

ANNEX A

DETAILS OF PRODUCTION AUXILIARY EQUIPMENT

Inlet System Air Filter System Inlet Silencer	Optional
Exhaust System Piping Silencer Exhaust Pipes	Test Bench Equipment
Fuel Feed Pump	Optional
Fuel Injection Equipment Prefilter Filter	Yes, or test bench equipment
Electrical Equipment	If necessary

INFORMATION TO BE INCLUDED
IN TEST REPORT

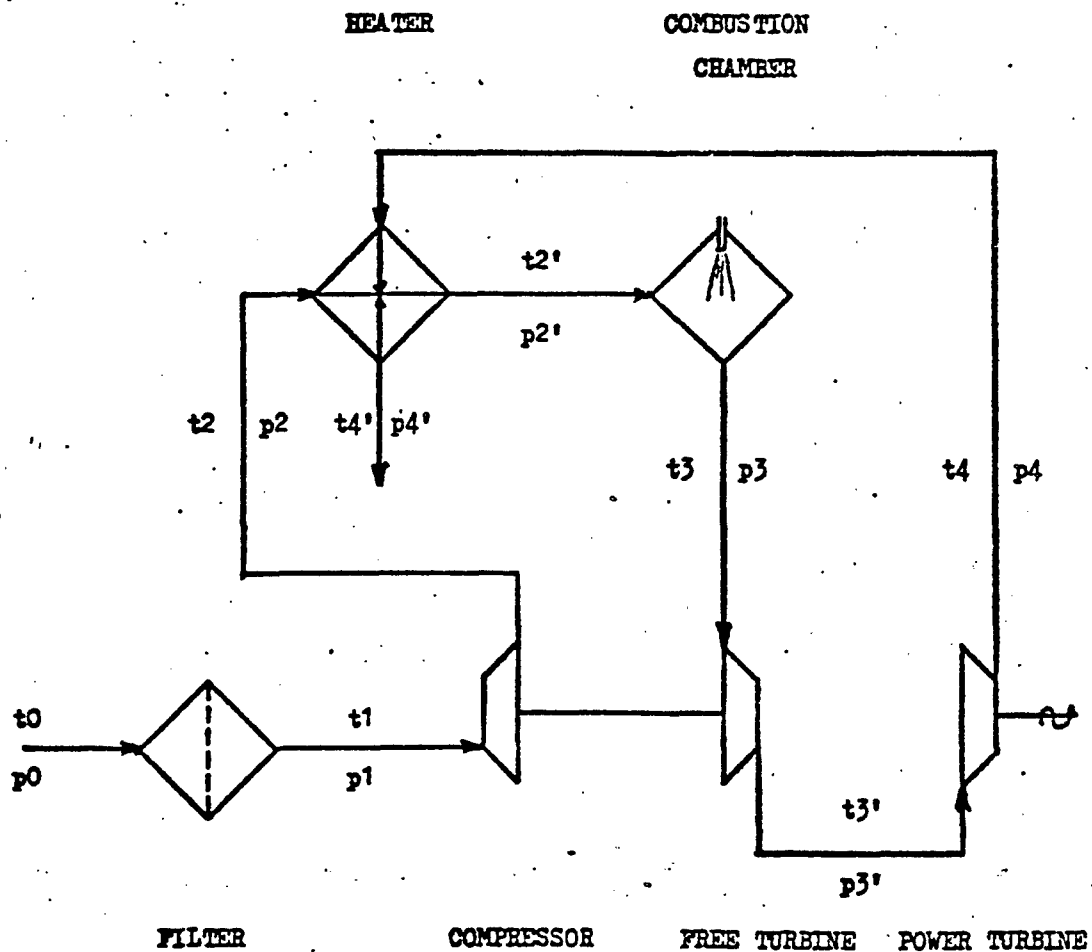
A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets and a summary with a list of faults and the remedial action taken.
6. An engine condition report at end of test with photographs of the condition of major parts such as combustion chamber, compressor wheels and diffusers, turbine wheels and nozzles, reduction gear with any other components of interest.
7. A history chart of lubricating oil used during the endurance tests.
8. Analysis of new and used lubricating oil, the latter to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. Any other relevant data.

SCHEMATIC DIAGRAM

t_0 and p_0	:	ambiente	temperature and pressure
t_1 and p_1	:	temperature and pressure	after filter
t_2 and p_2	:	"	" after compressor
t_2' and p_2'	:	"	" after heater
t_3 and p_3	:	"	" after combustion chamber
t_3' and p_3'	:	"	" after free turbine
t_4 and p_4	:	"	" after power turbine
t_4' and p_4'	:	exhaust gas	temperature and pressure



NATO UNCLASSIFIED

NATO STANDARD ENGINE LABORATORY TEST
(DIESEL and GASOLINE ENGINES)

AEP-5

EDITION JUNE 80

NATO UNCLASSIFIED

D-12

CHAPTER 1

PURPOSE AND APPLICABILITY

SECTION 1-1 - PURPOSE

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyse the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follows : "Power rating Kw (... metric HP) at r.p.m., in accordance with NATO code AEP 5. Edition June 1980".

SECTION 1-2 - APPLICABILITY

These test conditions apply to all service vehicle (combat and transport) propulsion Diesel and gasoline engines.

NOTE : SI units will be used.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception.

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

NOTES : (1) Engine measurements may be carried out before running-in.

(2) The manufacturer is responsible for defining the running-in programme and the engine should have been run-in before it is submitted for testing.

- (3) In so far as possible, the manufacturer's drawings and technical data will be supplied with the engine, to assist inspection and measurement of components.
- (4) It is normal practice for the engine to be given a preliminary performance test immediately after receipt, to check acceptability.
- (5) The initial, if accomplished, and final inspection of the engine should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

- a - Main values**
 - Speed
 - Torque (engine output shaft)
- b - Ambient conditions**
 - Temperature of ambient air
 - Atmospheric pressure
 - Humidity
- c - Air and gases**
 - Inlet air temperature
 - Induction or cylinder inlet depression
 - Inlet air flow (performance test only)
 - Air temperature and pressure in the inlet manifold
 - Exhaust temperature
 - Exhaust back-pressure
 - Gas temperatures at points influencing fuel control (if required)
- d - Lubrication and cooling**
 - Oil temperatures and pressures
 - Temperatures into and out of external coolers
 - Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations)
 - Oil consumption (during endurance tests only)
- e - Fuel**
 - Fuel temperature
 - Fuel consumption
- f - Miscellaneous**
 - Blow-by
 - Smoke density

2.1.3. Regulated parameters

Outlet liquid coolant temperatures :
 $96^{\circ}\text{C} \pm 3^{\circ}\text{C}$

Induction depression at rated power :
 25 ± 5 mbar

Exhaust back pressure at rated power :
 $40 \text{ mbar} \pm 5$

Fuel temperature at injection pump inlet :
 $30^{\circ}\text{C} \pm 3^{\circ}\text{C}$

2.1.4. TEST CONDITIONS

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than $\pm 1\%$ or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange (s) of the exhaust manifold (s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be taken preferably in the lubrication system, or, failing this, in the crank case. The measuring point will be specified in the test report.

Fuel temperature must be read at the injection pump inlet, or carburettor inlet.

Cooling condition for air cooled engine will be in accordance with manufacturers specification.

Auxiliary power take-offs may be loaded and measured if desired

2.1.5. MEASUREMENT ACCURACY

- TORQUE

The torque must be accurate within $\pm 0,5\%$ of the highest value to be measured.

- OUTPUT SPEED

Measurement must be accurate to within $\pm 0,5\%$.

- FUEL CONSUMPTION

$\pm 1\%$ for all apparatus used.

- TEMPERATURES

Intake air $\pm 1^{\circ}\text{C}$.

- PRESSURE

Atmospheric pressure ± 0.7 mbar

Air and gas pressure ± 50 mbar

Induction and exhaust pressure and depression $\pm 0,250$ mbar

Pressure of other fluids ± 250 mbar

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at Annex A).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, the fifth setting being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speed as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the Robert BOSCH Scale (or equivalent) shall not exceed 4.5.

No correction factor will be applied and the test results must include air temperature and atmospheric pressure.

The inlet air temperature shall be maintained as close as possible to 25°C .

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

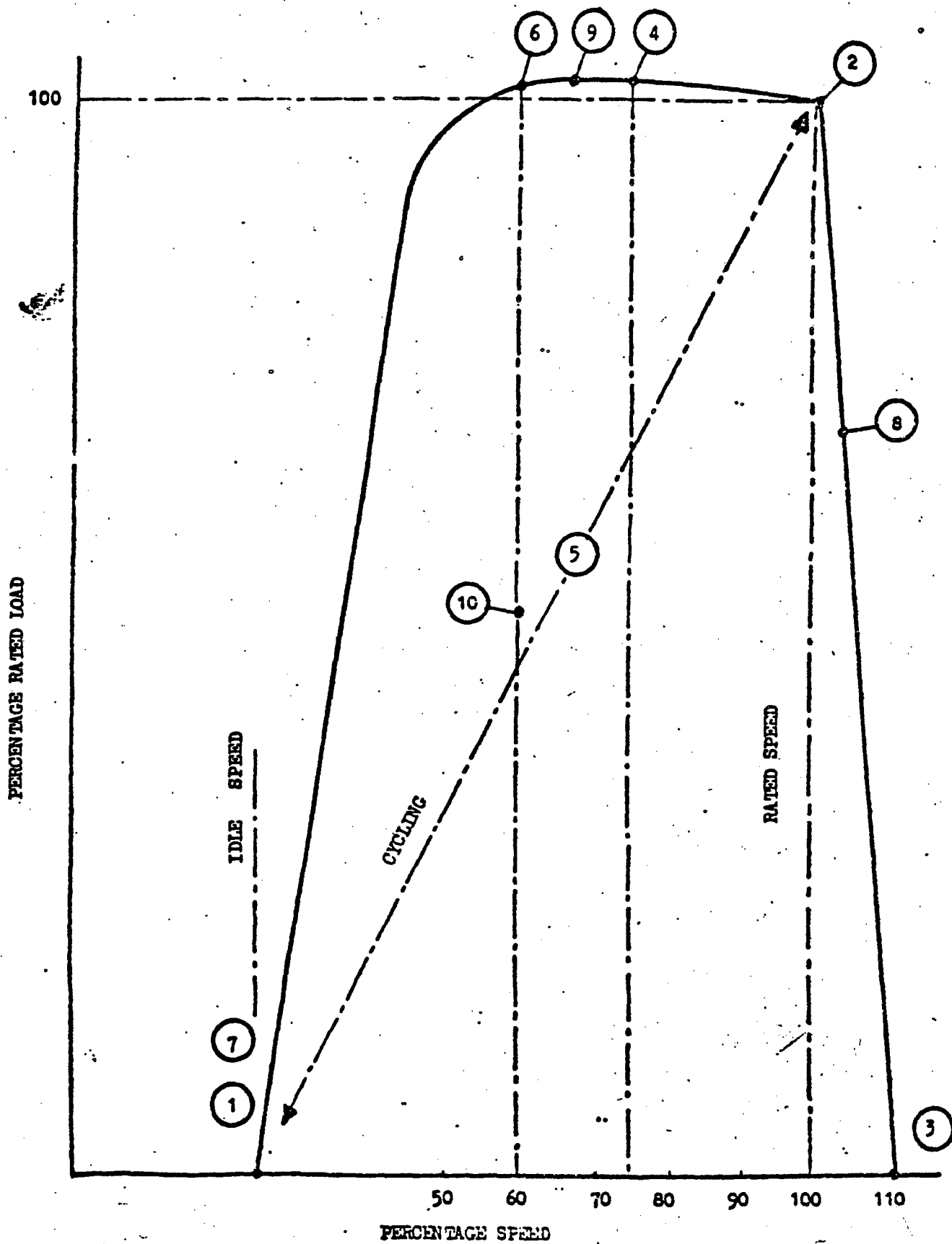
- 2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.
- 2.4.3. Engine oil and filters shall be changed after each 100 hour period.
- 2.4.4. The coolant outlet temperature is to be held at $96^{\circ}\text{C} \pm 3^{\circ}\text{C}$ or a higher temperature if proposed by the manufacturer. The coolant is to be water plus antifreeze in equal volume.
- 2.4.5. The engine oil temperature is to be measured in the lubrication system. The temperature measurement location shall be specified.
- 2.4.6. The four 100 hour periods which make up the endurance test are to be carried out with the reference fuel defined in Chapter 3.
- 2.4.7. Each 100 hour period is to comprise ten 10 hour cycles. Each 10 hour cycle will be carried out in accordance with the programme (section 2-5).
- 2.4.8. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10 hours cycle, with the exception of sub-cycle 5.
- 2.4.9. No interruptions are permitted during any of the sub-cycles, but the engine may be switched off on completion of any sub-cycle.

SECTION 2-5 - PROGRAMME OF 10 HOUR CYCLE

Sub Cycle	% Rated Speed	% Load (3)	Duration in hours
1	IDLE	0	$\frac{1}{2}$
2	100	100	2
3	governed speed (1)	0	$\frac{1}{2}$
4	75	100	1
5	IDLE $\longleftrightarrow$ 100	0 $\longleftrightarrow$ 100 4 MIN 6 MIN	2
6	60	100	$\frac{1}{2}$
7	IDLE	0	$\frac{1}{2}$
8	governed speed (2)	70 (3)	$\frac{1}{2}$
9	Max torque speed	100	2
10	60	50 (3)	$\frac{1}{2}$
Total			10

NOTES :

- (1) The speed shall be that attained with the engine at full throttle and with minimum load (residual brake load).
- (2) The speed shall be the steady speed of the engine at full throttle and 70 % load.
- (3) Part loads (70 and 50 %) shall be taken from the initial performance test.



CHAPTER 3

FUELS AND LUBRICANTS AND ANTIFREEZES

- 301 Engines are to be tested on Reference Fuels and Lubricants and antifreezes as specified by the relevant NATO Authority.

CHAPTER 4

DEFINITION OF TEST FAILURE

- 401 A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the test or that brings about as loss of power which cannot be rectified to give at least 95 % of rated power.
- Any major failure will lead to termination of the test and any retest must start at 0 hour.
- Major failures and corrective action are to be reported to the proper National Authority.
- 402 A minor failure is a defect which leads to a loss of power or degradation of the operation of the engine and which it is possible to remedy within the scope of normal maintenance and adjustment. If 95 % of the rated power cannot be obtained after normal maintenance then the test will be terminated. The minor failures and the measures taken to overcome them must be included in the report.
- 403 The suitability of an engine for NATO AEP5 Approval is to be the responsibility of the National Authorities after completion of the 400 hours test and consideration of the final condition of the engine.

DETAILS OF PRODUCTION AUXILIARY EQUIPMENT

(To be included as applicable)

Inlet system Inlet manifold Air filter } Inlet silencer } Blowby gas recirculation intake ... }	Yes Optional
Exhaust system Manifold Piping } Silencer } Exhaust pipes }	Yes Test bench equipment
Fuel feed pump	Yes
Carburettor	Yes (details of adjustment will be specified)
Ignition system Distributor Spark-plugs Coils Suppressor	Yes Yes Yes Yes
Fuel injection equipment Prefilter } Filter } Pump High-pressure pipes Injector	Yes or test bench equipment Yes Yes Yes

Liquid cooling equipment Radiator } Fan } Water pump Thermostat	 No Yes Yes
Air cooling equipment Streamlining Blower Temperature regulating device	 Yes Yes Yes
Electrical equipment	If necessary
Supercharging equipment Compressor driven directly or indirectly by the engine and/or exhaust gas Charge cooler Cooling pump or fan (engine driven) Device for regulating flow of cooling fluid	 Yes Yes Yes Yes

INFORMATION TO BE INCLUDED

IN TEST REPORT

A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

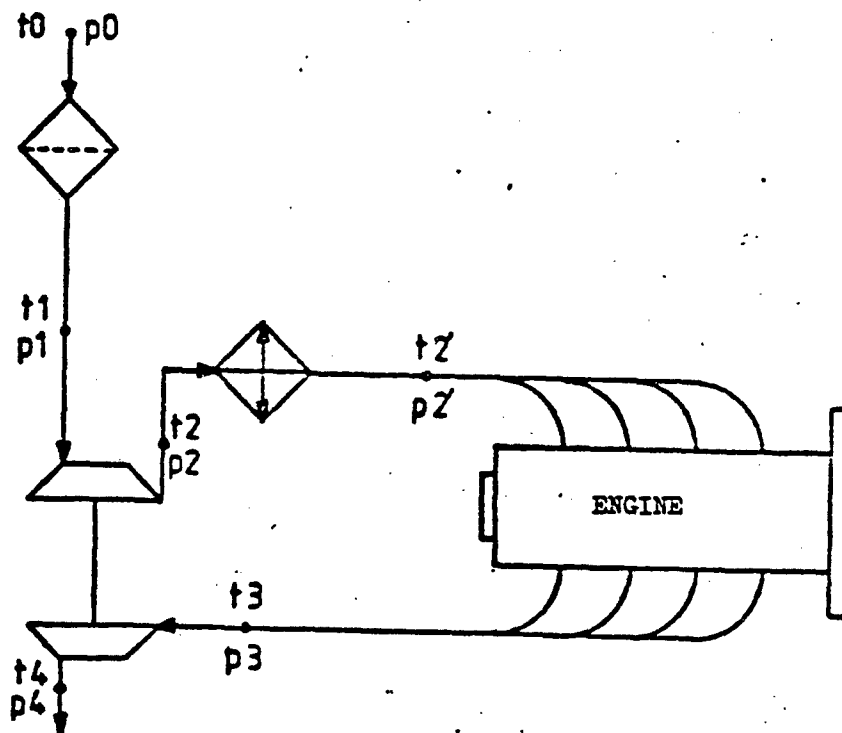
The report will also include the following :

1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets and a summary with a list of faults and the remedial action taken.
Full load performance data will be show in the format indicated.
6. An engine condition report at end of test with photographs of the condition of major parts such as pistons, bearings, valves, camshafts, crankshafts, cylinder bores together with any other components of interest.
7. A history chart of lubricating oil used during the endurance tests.
8. Analysis of new and used lubricating oil, the latter to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. Any other relevant data.

ENGINE		Type: _____	Nº. _____		Place date: _____			
FULL CHARGE PERFORMANCES					Reference: _____			
INITIAL ☐ FINAL ☐								
FUEL :			OIL type: _____			BRAKE type: _____		
Volume mass: _____ kg/cm ³			grade: _____					
AMBI- ENT	t0	°C						
	p0	mbar						
PERFORMANCE	n	r.p.m						
	M	mdaN						
	p	kw						
	pme	bar						
FUEL	Cs/bshc	g/kwh						
	Qc	mm ³ /cycle						
	qm	kg/h						
OIL	tM	°C						
	pM	bar						
WATER	te	°C						
	ts	°C						
INLET	t1	°C						
	p0 - p1	mbar						
	t2	°C						
	p2	bar						
	t2'	°C						
	p2 - p2'	mbar						
EXHAUST	t3	°C						
	p3	bar						
	t4	°C						
	p4 - p0	mbar						
	Smoke	bshch						
BLOW - BY		cm ³ /r.p.m						

DEFINITION OF SHORTS

. t_0	: ambient temperature	. t_1	: air temperature after filter (or compressor inlet)
. p_0	: ambient pressure	. $p_0 - p_1$	: inlet depression
. n	: engine speed	. t_2	: compressor discharge temperature
. M	: engine torque	. p_2	: compressor discharge pressure
. P	: output power	. t_2'	: air temperature after charge cooler
. p_{me}/b_{mep}	: brake mean effective pressure	. $p_2 - p_2'$	: pressure of across charge cooler
. C_s/b_{sfc}	: specific fuel consumption	. t_3	: exhaust gas temperature (turbine inlet)
. Q_c	: volume of fuel per injection	. p_3	: exhaust gas pressure (turbine inlet)
. q_m	: mass fuel flow per hour	. t_4	: turbine discharge temperature
. t_H	: oil temperature	. $p_4 - p_0$	: Exhaust back pressure
. p_H	: oil pressure		
. t_e	: coolant temperature into engine		
. t_s	: coolant temperature out of engine		



APPENDIX E

LUBE OIL SPECTROGRAPHIC ANALYSIS

Sent to this address

OIL ANALYSIS REQUEST		KEYPUNCH CODE
OIL ANALYSIS LAB New Cumberland STSGP-PE		1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/MAKE Cummins V1A-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE LAB ☐ ROUTINE ☐ REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION TAKEN SAMPLE - 5		
DISC REFANT ITEM TAKEN AT 126.5 HRS		
HOW MALFUNCTIONED OF ENDURANCE		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☒ HOT ☐ COLD	TYPE OIL MIL-L-2104C (30W)
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance. 216		
FOR LAB USE ONLY		
SAMPLE RESPONSE TIME		39-40
FE 41-43 23	AG 44-46 0	AL 47-49 0
CR 50-52 6	CU 53-55 6	MG 56-58 809
NI 59-61 2	PD 62-64 14	SI 65-67 4
SN 68-70 2	TI 71-73 0	MO 74-76 1
LAB RECOMMENDATION		77-78
SAMPLE NO. 177	SIGNATURE	FILE MAINT 79
		DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSCP-PE	1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
	EQUIPMENT MODEL/ANAL Cummins VIA-903 Engine	11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)		LOCAL TIME SAMPLE TAKEN
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE LAB ☐ TEST ☐ OTHER ☐ ☐ ROUTINE ☐ REQUEST ☐ CELL ☐ (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pis, Qts, Gals)		
ACTION TAKEN SAMPLE (6) TAKEN AT		
DISCREPANT ITEM 150 HOURS OF ENDURANCE		
HOW MALFUNCTIONED		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☒ HOT ☐ COLD	TYPE OIL 37-3 MIL-2104C (30W)
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.		
FOR LAB USE ONLY		
SAMPLE RESPONSE TIME		39-40
FE 41-43 34	AG 44-46 0	AL 47-49 0
CR 50-52 7	CU 53-55 8	MG 56-58 922
NI 59-61 3	PB 62-64 21	SI 65-67 4
SN 68-70 0	TI 71-73 0	MO 74-76 2
LAB RECOMMENDATION		77-78
SAMPLE NO. 178	SIGNATURE	FILE MAINT 79
		DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSCP-PE			1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/APO) PODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8548			5-10
EQUIPMENT MODEL/ARI Cummins VTA-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./EIC				
DATE SAMPLE TAKEN (Day, Mo, Yr)		LOCAL TIME SAMPLE TAKEN		21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB ☐ TEST OTHER ☐ (Specify)				34
☐ ROUTINE ☐ REQUEST ☐ CELL				35
OIL ADDED SINCE LAST SAMPLE (Pis, Qts, Gals)				36
ACTION SAMPLE 7 TAKEN AT				37
DISCREPANT ITEM 176.5 HOURS OF				38
HOW MALFUNCTION ENDURANCE				39
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				40
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☒ HOT ☐ COLD		41-42
		TYPE OIL MIL-2104C (90wt)		43-44
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME				45-46
FE 41-43	PG 44-46	AL 47-49	CR 50-52	CU 53-55
48	0	0	10	11
MG 56-58	NI 59-61			
934	3			
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76
30	4	11	0	0
LAB RECOMMENDATION				77-78
SAMPLE NO. 179		SIGNATURE		FILE MAINT 79
				DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/API) (DDAAD) DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528			5-10
EQUIPMENT MODEL/APL CUMMINS VTA-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./EIC				
DATE SAMPLE TAKEN (Day, Mo., Yr)		LOCAL TIME SAMPLE TAKEN		21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB ☐ ROUTINE ☐ REQUEST ☐ TEST ☐ OTHER (Specify)				34
OIL ADDED SINCE LAST SAMPLE (Qty, Qts, Gals)				35-36
ACTION TAKEN SAMPLE 8 TAKEN AT				
DISCREPANCY 200 HRS OF ENDURANCE				
HOW MALFUNCTIONED				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TURP	SAMPLE TEMPERATURE ☒ HOT ☐ COLD		TYPE OIL MIL-2104C (30wt.)	
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance. 237/12				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME				39-40
FE 41-43 63	AG 44-46 0	AL 47-49 0	CR 50-52 12	CU 53-55 16
PH 62-64 40	SI 65-67 5	SN 68-70 0	TI 71-73 0	MO 74-76 0
LAB RECOMMENDATION				77-78
SAMPLE NO. 180	SIGNATURE		FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2026. PREVIOUS EDITION WILL BE USED

XAL BURN AND PRINT OIL ANALYSIS *SAMPLE 5*
 MP TYPE COMP SER NUMBER DATE TRANSIT OSOH OSOC *TAKEN AT*
 NG 36.9LIH 0177 3153 00 0127 000 *126.5 HRS.*
 FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
 023 000 000 000 006 006 809 002 002 014 004 002 000 183 000 000 002 001 022 421

LOCAL BURN AND PRINT
 COMP TYPE COMP SER NUMBER DATE TRANSIT OSOH OSOC *SAMPLE 6*
 DENG 36.9LIH 0178 3153 00 0150 000 *TAKEN AT*
 FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN *150 HRS.*
 034 000 000 000 007 008 922 002 003 021 004 000 000 169 000 000 000 002 011 512

LOCAL BURN AND PRINT
 COMP TYPE COMP SER NUMBER DATE TRANSIT OSOH OSOC *SAMPLE 7*
 DENG 36.9LIH 0179 3153 00 0177 000 *TAKEN AT*
 FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN *176.5 HOURS*
 048 000 000 000 010 011 934 003 003 030 004 011 000 150 000 000 000 024 500

LOCAL BURN AND PRINT
 COMP TYPE COMP SER NUMBER DATE TRANSIT OSOH OSOC *SAMPLE 8*
 DENG 36.9LIH 0180 3153 00 0200 000 *TAKEN AT*
 FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN *280 HRS*
 063 000 000 000 012 016 948 003 003 040 005 000 000 127 000 000 000 024 438

OIL ANALYSIS REQUEST						KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGE-FE					1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090					4
	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGED Mr. R. Rimpela Warren, Michigan 48090 AYN: 786-8528					5-10
EQUIPMENT MODEL (APL) CUMMINS VIA-903 Engine						11-14
EQUIPMENT SER. NO.						15-20
END ITEM MODEL/HULL NO.						
END ITEM SER. NO./PIC						
DATE SAMPLE TAKEN (Day, Mo., Yr)					LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 hour NATO Test						25-29
HOURS/MILES SINCE OIL CHANGE						30-34
REASON FOR SAMPLE LAB ☐ TEST ☐ OTHER ☐ (Specify)						35-39
☐ ROUTINE ☐ REQUEST ☐ CELL						
OIL ADDED SINCE LAST SAMPLE (Pnt, Qts, Galts)						35-39
ACTION TAKEN SAMPLE - 9						
DISCRIPTION ITEM TAKEN AT 226.5 HOURS OF						
HOW MALFUNCTIONED ENDURANCE						
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW						
HOW TAKEN ☐ DRAIN ☐ TUGS		SAMPLE TEMPERATURE ☒ HOT ☐ COLD		TYPE OIL MIL-L-2104C (30 wt)		37-39
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.						
FOR LAB USE ONLY						
SAMPLE RESPONSE TIME 22						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
21	0	2	6	6	700	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
10	3	0	0	3		
LAB RECOMMENDATION						77-78
SAMPLE NO. 101		SIGNATURE		FILE MAINT 79	DATA SEQ 80	

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/AFPO) DODAAD DRSTA-RGRD Mr. R. Rimpela			5-10
	Warren, Michigan 48090 AVN: 786-8528			
EQUIPMENT MODEL/APP Cummins V1A-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./EIC				
SMALL SAMPLE TAKEN (Qty, Mo., Yr)			LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB ☐ TEST ☐ OTHER ☐ ☐ ROUTINE ☐ REQUEST ☐ CELL ☐ (Specify)				34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)				35-36
ACTION TAKEN SAMPLE 10				
OIL TESTED ITEM TAKEN AT 250 HRS OF				
HOW MALFUNCTIONED ENDURANCE				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☒ HOT ☐ COLD		TYPE OIL 11-38 (MIL-1-214C-304)
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME 223/72				39-40
FE 41-43 27	AG 44-46 0	AL 47-49 2	CR 50-52 7	CU 53-55 7
MG 56-58 755	NI 59-61 3	PD 62-64 11	SI 65-67 3	SN 68-70 6
TI 71-73 0	MO 74-76 3	LAB RECOMMENDATION		77-78
SAMPLE NO. 100	SIGNATURE	FILE MAINT 79	DATA SEQ 80	

DD FORM 1 NOV 77 2025 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include Zip Code/APO) 100DAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528			5-10
EQUIPMENT MODEL/AVL Cummins V1A-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./EIC				
DATE SAMPLE TAKEN (Day, Mo., Yr)			LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB ☐ ROUTINE ☐ REQUEST ☐ TEST ☐ CELL ☐ OTHER (Specify)				34
OIL ADDED SINCE LAST SAMPLE (Pss, Qts, Gals)				35-36
ACCOMPLISH SAMPLE 11				
DISCREPANCY ITEM TAKEN AT 276.5 HRS				
HOW MALFUNCTIONED OF ENDURANCE				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☒ HOT ☐ COLE		TYPE OIL MIL-L-2104C (77.30)
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME 100/70				39-40
FE 41-43 36	AG 44-46 0	AL 47-49 4	CR 50-52 10	CU 53-55 10
MG 56-58 638	NI 59-61 3			
PB 62-64 17	SI 65-67 4	SN 68-70 19	TI 71-73 0	MO 74-76 4
LAB RECOMMENDATION				77-78
SAMPLE NO. 98	SIGNATURE		FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-PCRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528			5-10
EQUIPMENT MODEL/MAKE Cummins VIA-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./KIC				
DATE SAMPLE TAKEN (Day, Mo., Yr)		LOCAL TIME SAMPLE TAKEN		21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB ☐ ROUTINE ☐ REQUEST ☐ TEST CELL ☐ OTHER (Specify)				34-37
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)				38-39
ACTION TAKEN SAMPLE 12				
TAKEN AT 300 HOURS				
OF ENDURANCE				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☒ HOT ☐ COLD		37-39
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME				39-40
FE 41-43 52	AG 44-46 0	AL 47-49 4	CR 50-52 11	CU 53-55 13
PG 62-64 24	SI 65-67 4	SN 68-70 0	TI 71-73 0	MO 74-76 3
LAB RECOMMENDATION				77-78
SAMPLE NO. 99	SIGNATURE		FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

UTJ8Z

COMP TYPE COMP SER NUMBER DATE TRANSIT OSCH OSOC SAMPLE *SAMPLE 11*
DENG VTA903 0098 3174 33 0000 276 F *TAKEN AT 276.5 HRS*

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
036 000 004 000 010 010 638 004 003 017 004 019 000 099 000 000 000 004 014 013

UTJ8Z

COMP TYPE COMP SER NUMBER DATE TRANSIT OSCH OSOC SAMPLE *SAMPLE 12*
DENG VTA903 0099 3174 33 0000 300 F *TAKEN AT 300 HRS*

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
052 000 004 000 011 013 800 004 003 024 004 000 000 090 000 000 000 003 006 029

UTJ8Z

COMP TYPE COMP SER NUMBER DATE TRANSIT OSCH OSOC SAMPLE *SAMPLE 10 TAKEN*
DENG VTA903 0100 3174 33 0000 250 F *AT 250 HRS*

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
027 000 002 000 007 007 755 003 003 011 003 006 000 127 000 000 000 003 013 026

UTJ8Z

COMP TYPE COMP SER NUMBER DATE TRANSIT OSCH OSOC SAMPLE *SAMPLE 9*
DENG VTA903 0101 3174 33 0000 226 F *TAKEN AT*
226.5 HRS

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
021 000 002 000 006 006 700 003 003 010 003 000 000 138 000 000 000 003 020 012

OIL ANALYSIS REQUEST						KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE					1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090					4
	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528					5-10
EQUIPMENT MODEL/APL Cummins V1A-903 Engine					11-14	
EQUIPMENT SER. NO.					15-20	
END ITEM MODEL/HULL NO.						
END ITEM SER. NO./LIC						
DATE SAMPLE TAKEN (Day, Mo., Yr)				LOCAL TIME SAMPLE TAKEN	21-24	
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test					25-29	
HOURS/MILES SINCE OIL CHANGE					30-33	
REASON FOR SAMPLE LAB ☐ ROUTINE ☐ REQUEST ☐ TEST ☐ OTHER ☐ CELL ☐ (Specify)					34	
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)					35-36	
ACTION TAKEN SAMPLE 13 TAKEN AT						
DISCREPANT ITEM 326 HRS OF ENDURANCE						
HOW MALFUNCTIONED						
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW						
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☐ HOT ☐ COLD		TYPE OIL		37-38
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.						
FOR LAB USE ONLY						
SAMPLE RESPONSE TIME 195/75					39-40	
FE 41-43 44	AG 44-46 0	AL 47-49 0	CR 50-52 7	CU 53-55 9	MG 56-58 955	NI 59-61 3
FB 62-64 15	SI 65-67 4	SN 68-70 0	TI 71-73 0	MO 74-76 4		
LAB RECOMMENDATION					77-78	
SAMPLE NO. 2155		SIGNATURE		FILE MAINT 79	DATA SEQ 80	

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE		
TO	OIL ANALYSIS LAB New Cumberland STSGP-FE			1-3		
FROM	MAJOR COMMAND TACOM, Warren, MI 48090			4		
	OPERATING ACTIVITY (Include ZIP Code/API) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528			5-10		
	EQUIPMENT MODEL/ANAL Cummins V1A-903 Engine			11-14		
EQUIPMENT SER. NO.				15-20		
END ITEM MODEL/HULL NO.						
END ITEM SER. NO./EIC						
DATE SAMPLE TAKEN (Day, Mo., Yr)		LOCAL TIME SAMPLE TAKEN		21-24		
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29		
HOURS/MILES SINCE OIL CHANGE				30-33		
REASON FOR SAMPLE LAB TEST OTHER ☐ ROUTINE ☐ REQUEST ☐ CELL ☐ (Specify)				34		
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)				35-36		
ACTION TAKEN						
DISCREPANT ITEM						
HOW MALFUNCTIONED						
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW						
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☐ HOT ☐ COLD		TYPE OIL	37-38		
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.						
209/75						
FOR LAB USE ONLY						
SAMPLE RESPONSE TIME				39-40		
FE 41-43	AG 44-46	AL 47-49	CU 50-52	CU 53-55	MG 56-58	NI 59-61
51	0	3	8	9	998	3
PD 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
17	5	0	0	5		
LAB RECOMMENDATION				77-78		
2155						
SAMPLE NO.	SIGNATURE		FILE MAINT 79	DATA SEQ 80		

DD FORM 2026 NOV 77 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
TO FROM	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/AFPO) DDIDAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVIL: 796-8528			5-10
EQUIPMENT MODEL/APP Cummins VIA-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./EIC				
DATE SAMPLE TAKEN (Day, Mo., Yr)			LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB TEST OTHER ☐ ROUTINE ☐ REQUEST ☐ CELL ☐ (Specify)				34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)				35-36
ACTION TAKEN				
DISCREPANCY ITEM				
HOW MALFUNCTIONED				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TUBE		SAMPLE TEMPERATURE ☐ HOT ☐ COLD		37-38
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME				39-40
FE 41-43 46	AG 44-46 0	AL 47-49 0	CR 50-52 9	CU 53-55 11
MG 56-58 788	NI 59-61 2			
PB 62-64 18	SI 65-67 4	SN 68-70 19	TI 71-73 0	MO 74-76 2
LAB RECOMMENDATION Please see k. [Signature]				77-78
SAMPLE NO. SP 22		SIGNATURE [Signature]		FILE MAINT [Signature]
				DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST				KEYPUNCH CODE
R O M	OIL ANALYSIS LAB New Cumberland STSGP-PE			1-3
	MAJOR COMMAND TACOM, Warren, MI 48090			4
	OPERATING ACTIVITY (Include ZIP Code/API's) IX311AAD DRSIA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528			5-10
EQUIPMENT MODEL/APP CUMMINS VIA-903 Engine				11-14
EQUIPMENT SER. NO.				15-20
END ITEM MODEL/HULL NO.				
END ITEM SER. NO./PIC				
DATE SAMPLE TAKEN (Day, Mo., Yr)		LOCAL TIME SAMPLE TAKEN		21-24
HOURS/MAILES SINCE OVERHAUL 400 Hour NATO Test				25-29
HOURS/MAILES SINCE OIL CHANGE				30-33
REASON FOR SAMPLE LAB TEST OTHER ☐ ROUTINE ☐ REQUEST ☐ CELL ☐ (Specify)				34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)				35-36
ACTION TAKEN SAMPLE 16 TAKEN				
DISCREPANT ITEM AT 400 HOURS				
HOW MALFUNCTIONED OF ENDURANCE				
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW				
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☐ HOT ☐ COLD		TYPE OIL	37-38
REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.				
FOR LAB USE ONLY				
SAMPLE RESPONSE TIME 227/74				39-40
PE 41-43 57	AG 44-46 0	AL 47-49 0	CR 50-52 10	CU 53-55 13
MG 56-58 823	NI 59-61 3			
PB 62-64 23	SI 65-67 4	SN 68-70 19	TI 71-73 0	MO 74-76 2
LAB RECOMMENDATION <i>Please to not change</i>				77-78
SAMPLE NO. SP 23	SIGNATURE		FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2028 PREVIOUS EDITION WILL BE USED

UTJ8Z FORMAT TO UPDATE SOAPIN FILE *SAMPLE 13*
 COMP TYPE COMP SER DAYS IN REASON FOR
 DEENG NUMBER DATE TRANSIT OSCH OSOC SAMPLE
 2155 3231 07 0000 326 400HFNATO *TAKEN AT 326 HRS*

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
 044 000 000 000 007 009 955 000 003 015 004 000 000 168 000 000 004 018 121

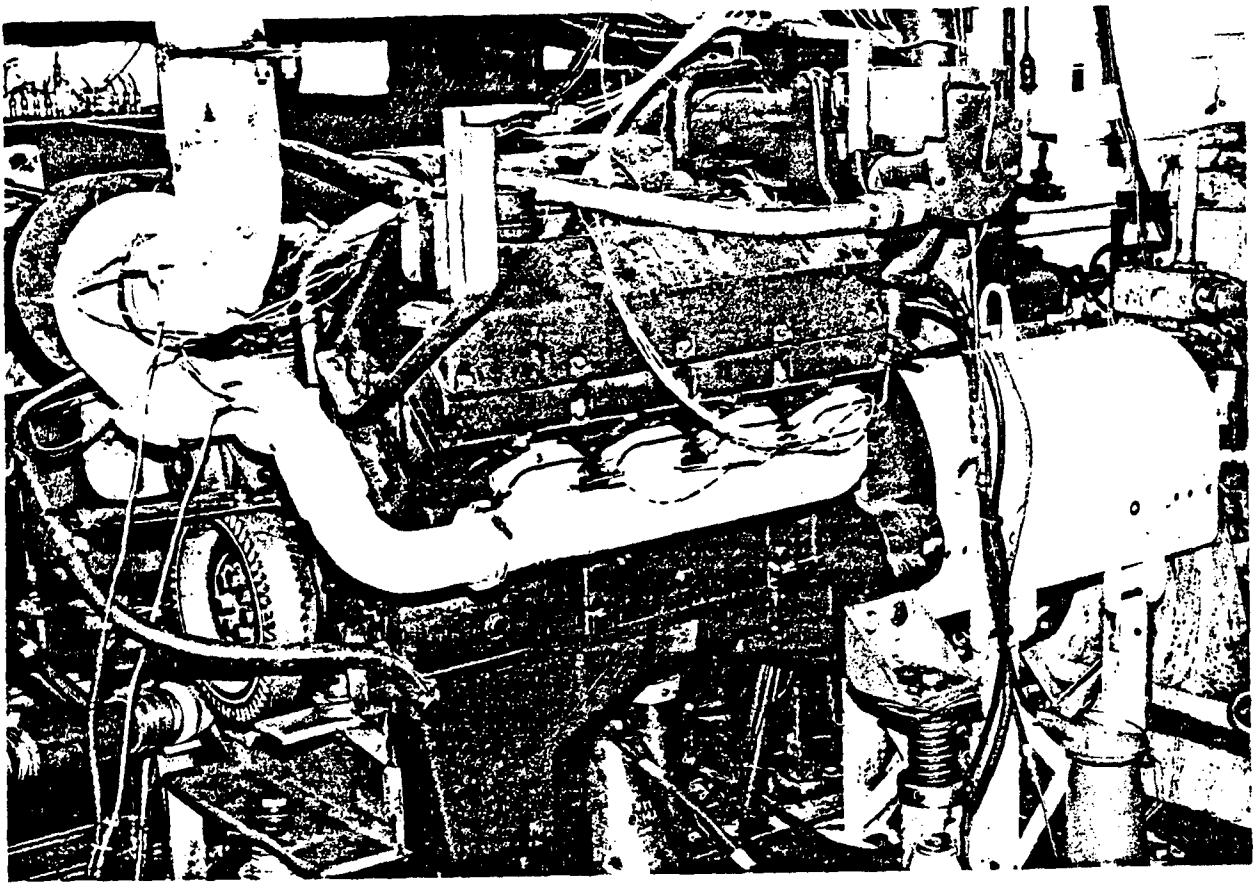
UTJ84 /FORMAT TO UPDATE SOAPIN FILE *SAMPLE 14*
 COMP TYPE COMP SER DAYS IN REASON FOR
 DEENG NUMBER DATE TRANSIT OSCH OSOC SAMPLE
 2156 3231 07 0000 350 400HFNATO *TAKEN AT 350 HRS*

FE AG AL BE CR CU MG NA NI PB SI SN TI B BA CD MN MO V ZN
 051 000 003 000 008 009 998 000 003 017 005 000 000 148 000 000 002 005 017 172

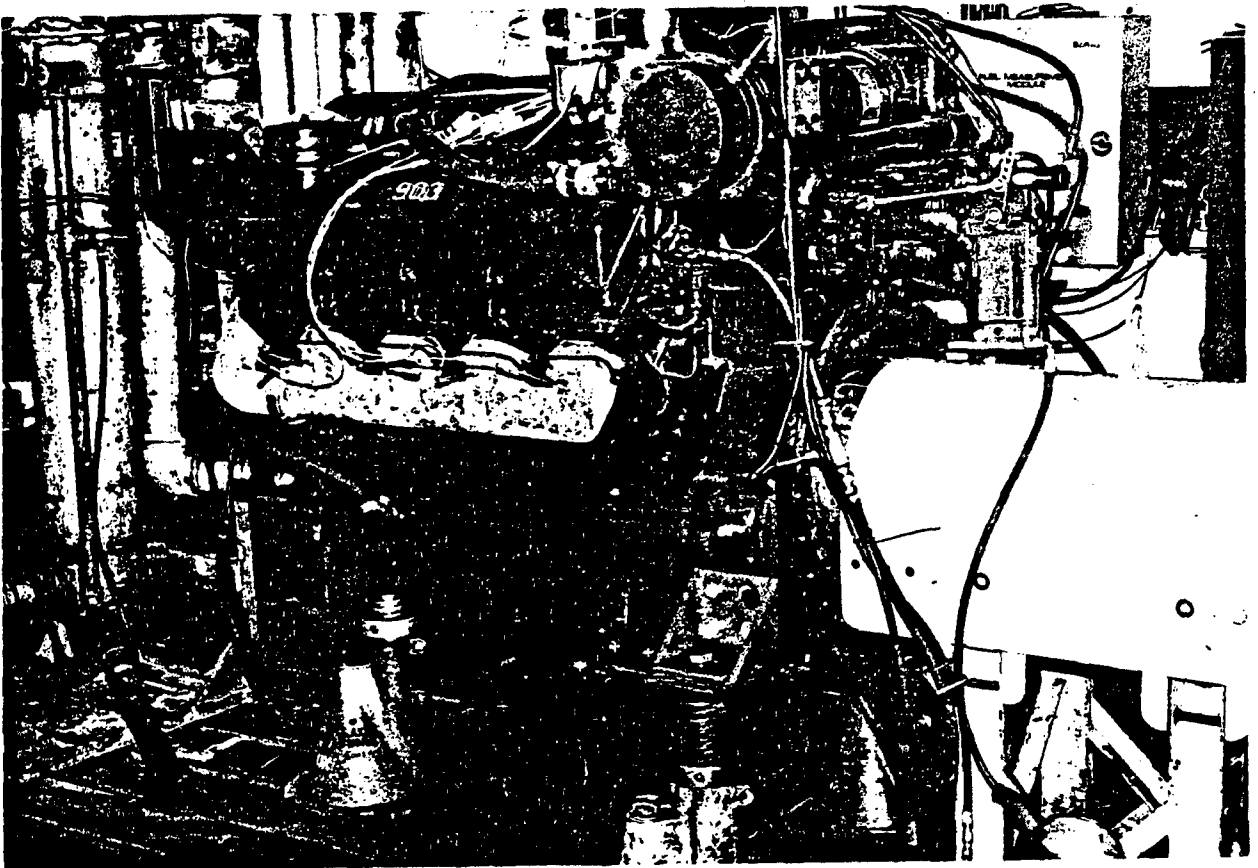
SAMPLE 15
TAKEN AT 375 HRS

SAMPLE 16
TAKEN AT 400 HRS

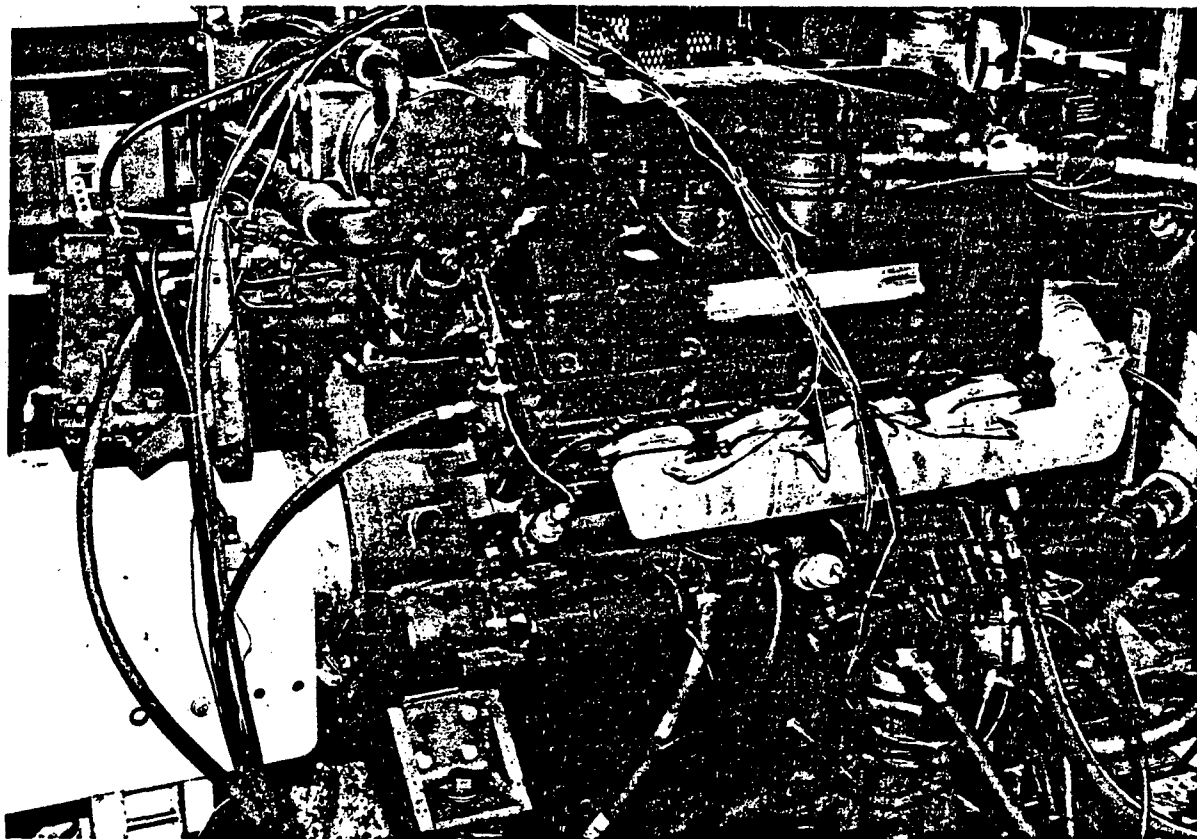
APPENDIX F - Photographs



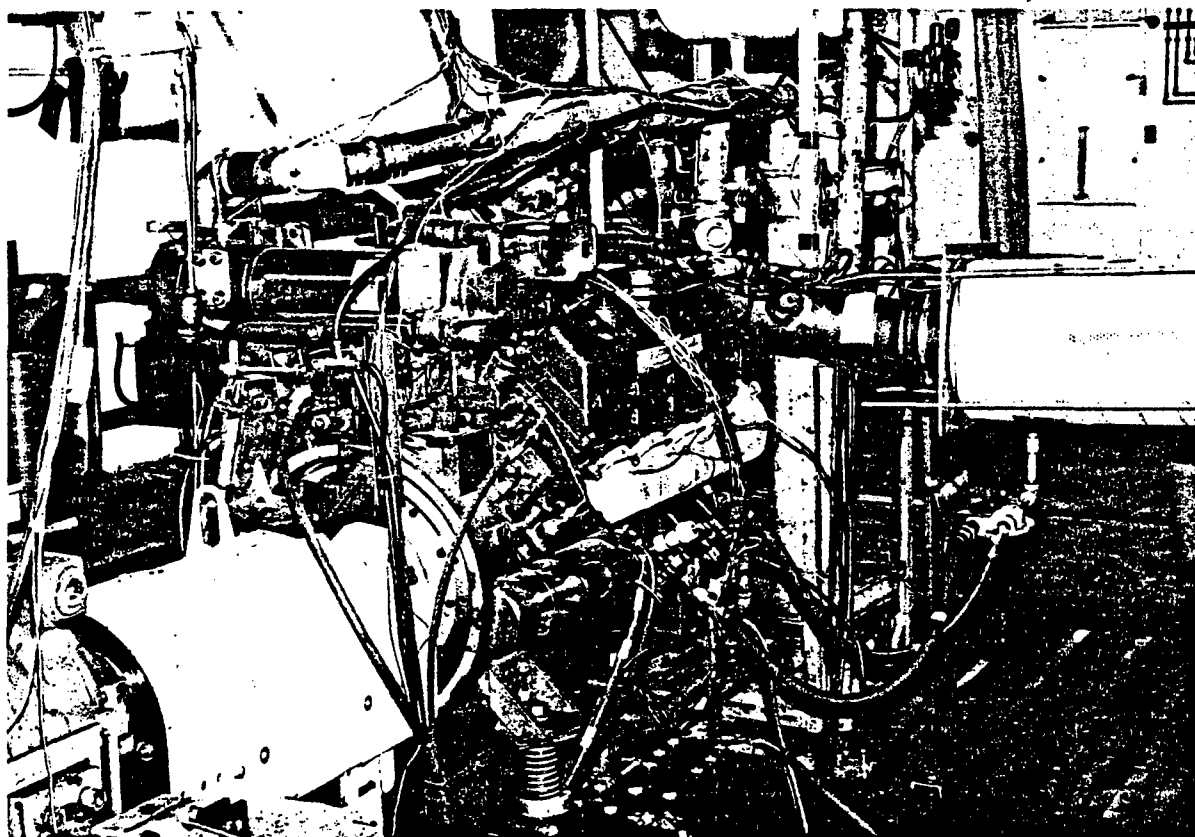
ENGINE TEST SET-UP, LEFT FRONT



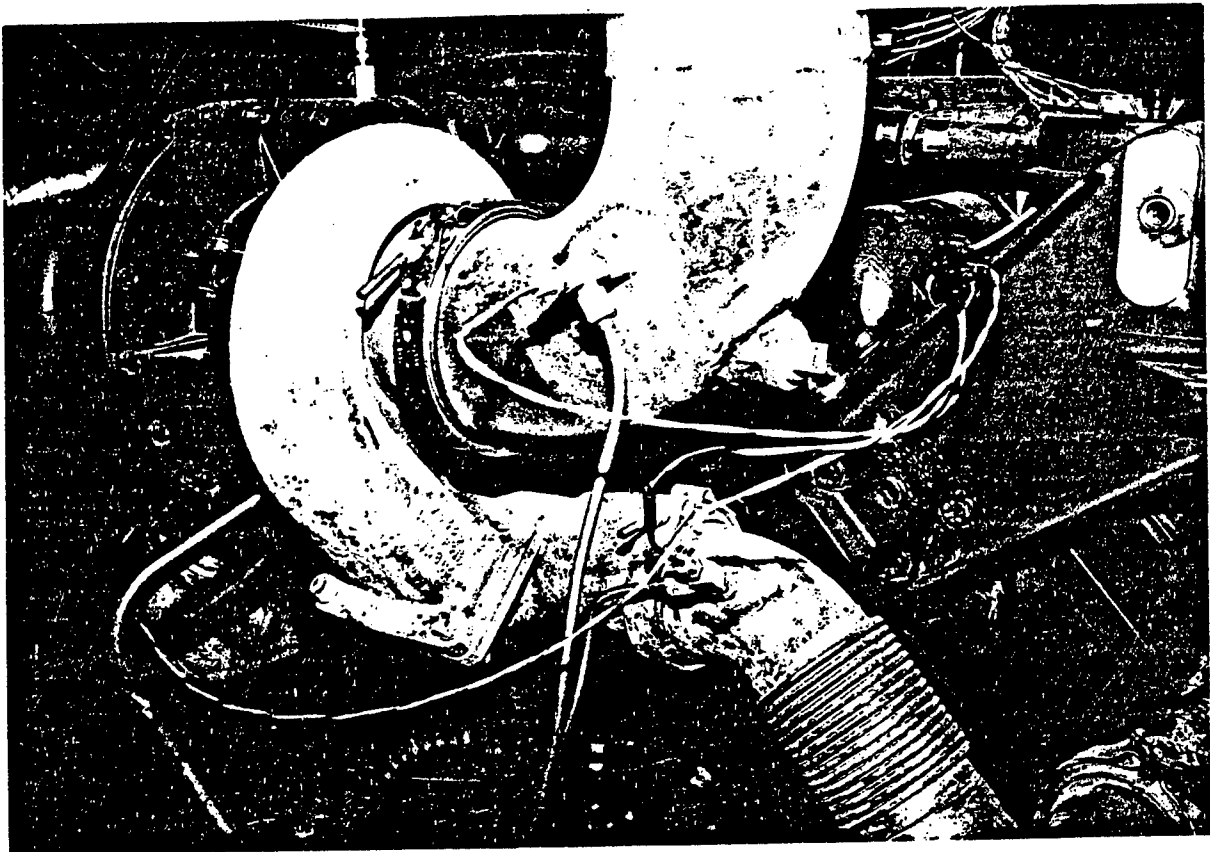
ENGINE TEST SET-UP, LEFT REAR



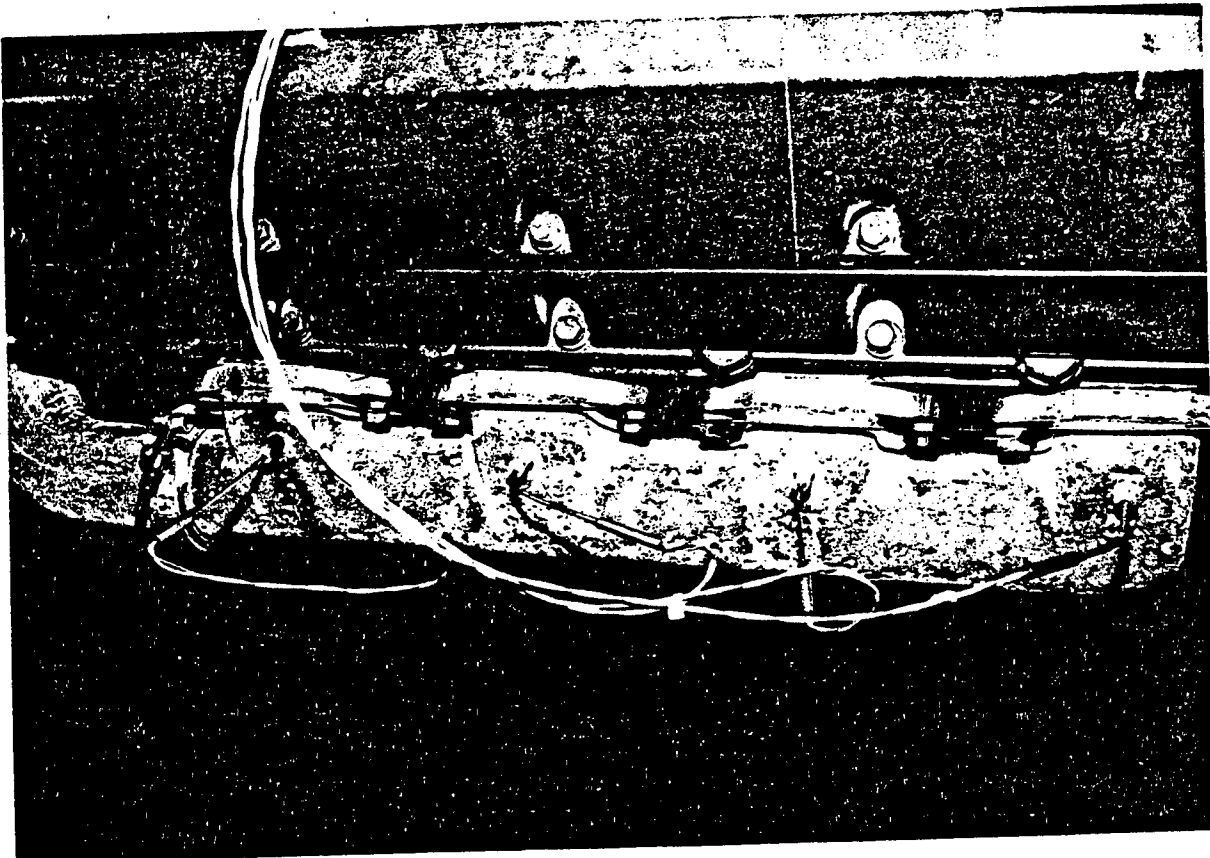
ENGINE TEST SET-UP, RIGHT SIDE



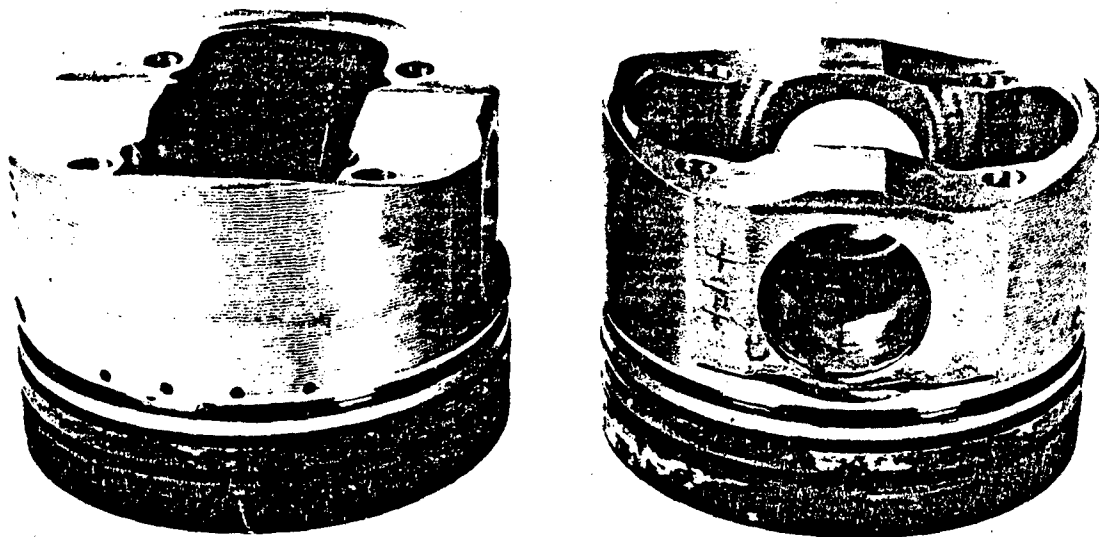
ENGINE TEST SET-UP, RIGHT REAR



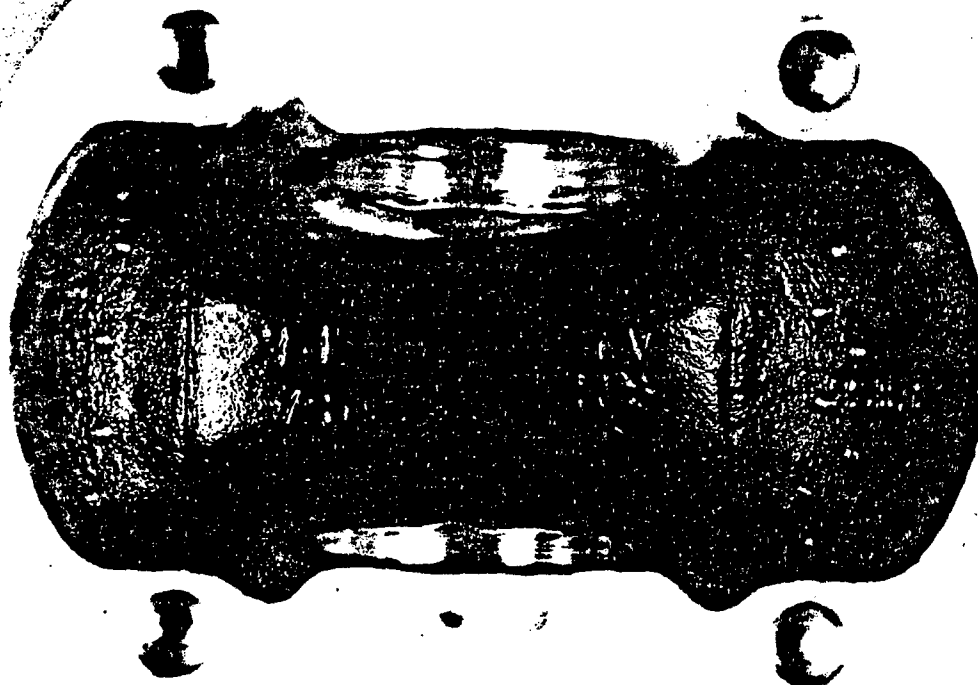
ENGINE TEST SET-UP, TURBOCHARGER



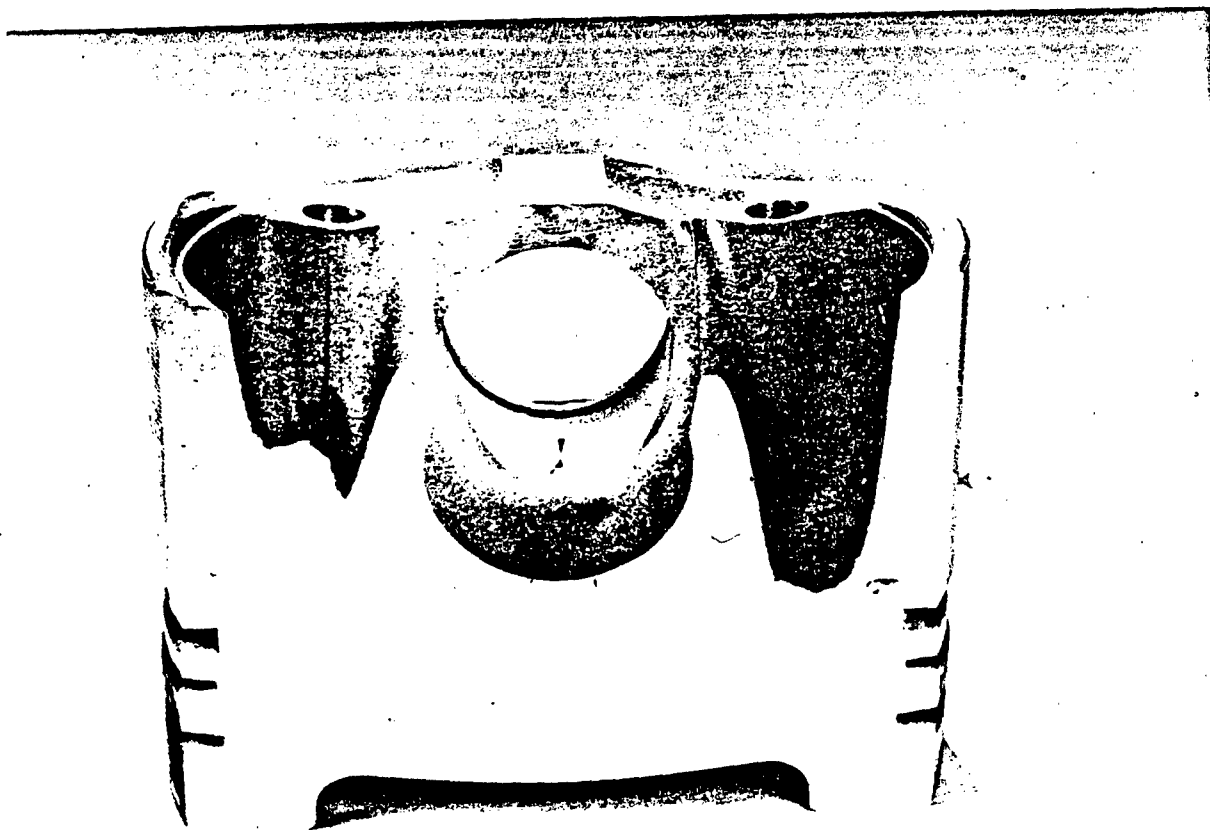
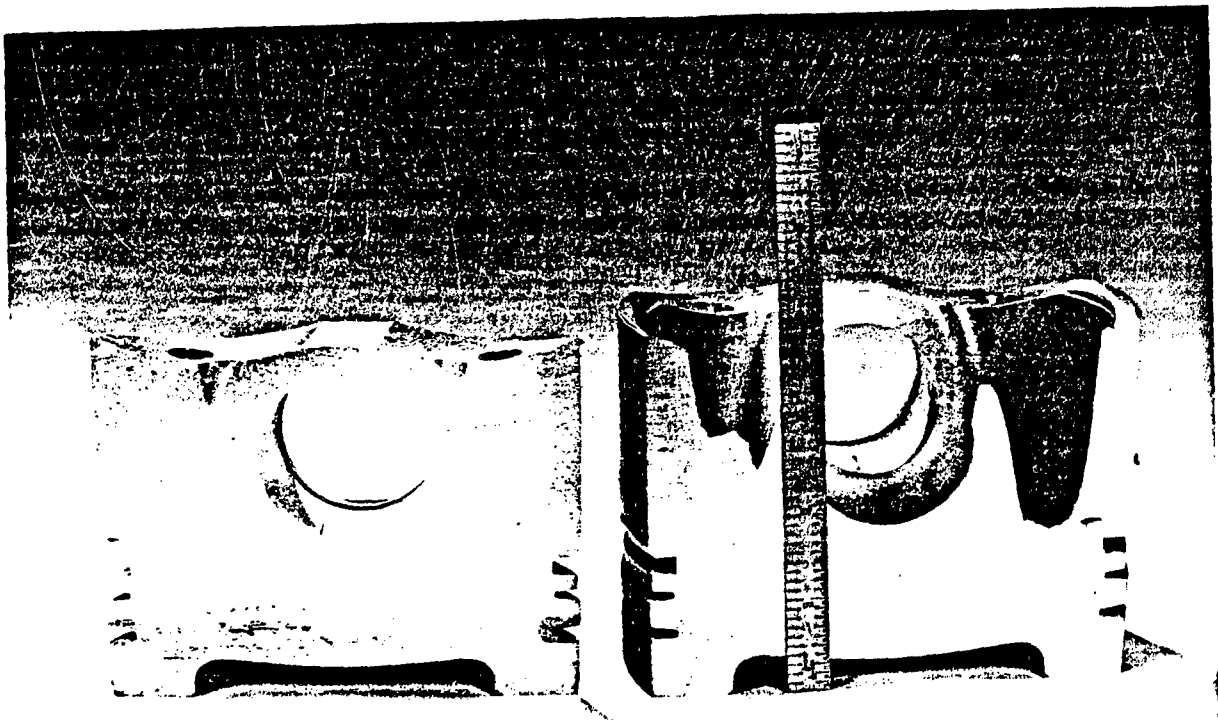
ENGINE TEST SET-UP, LEFT SIDE



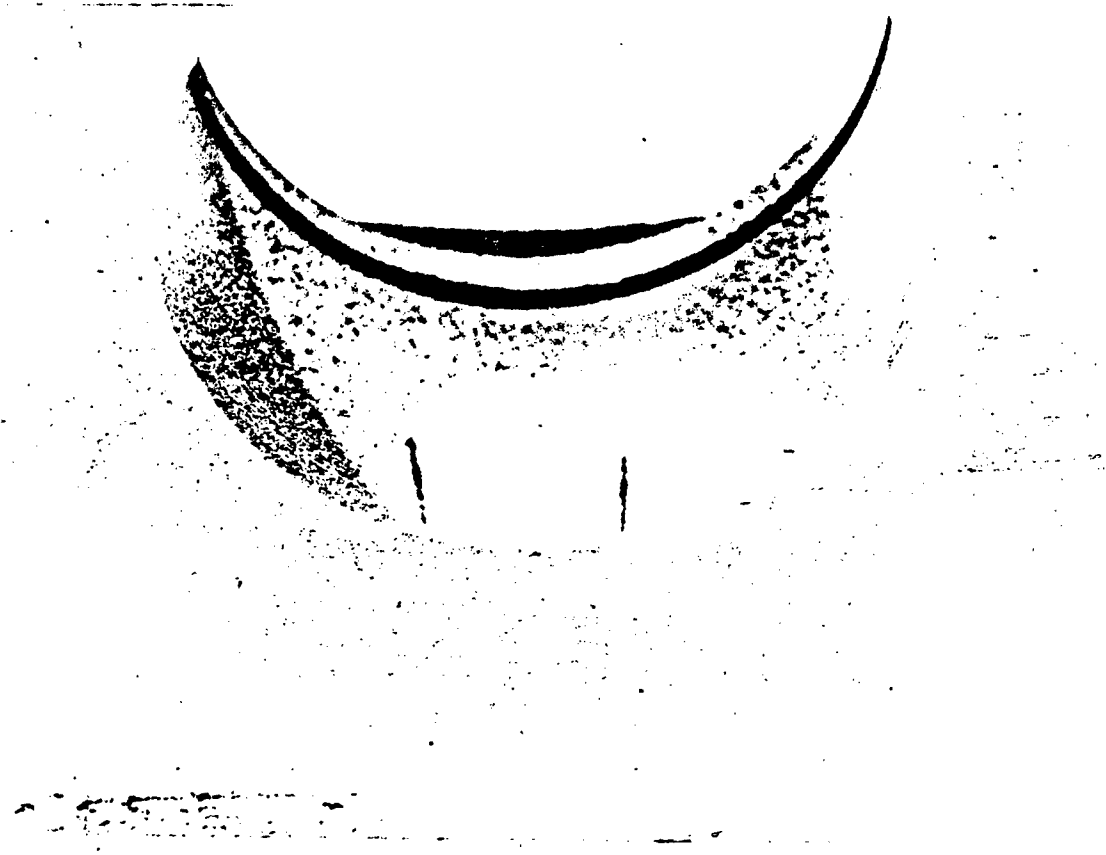
PISTONS - TYPICAL CLEAN APPEARANCE



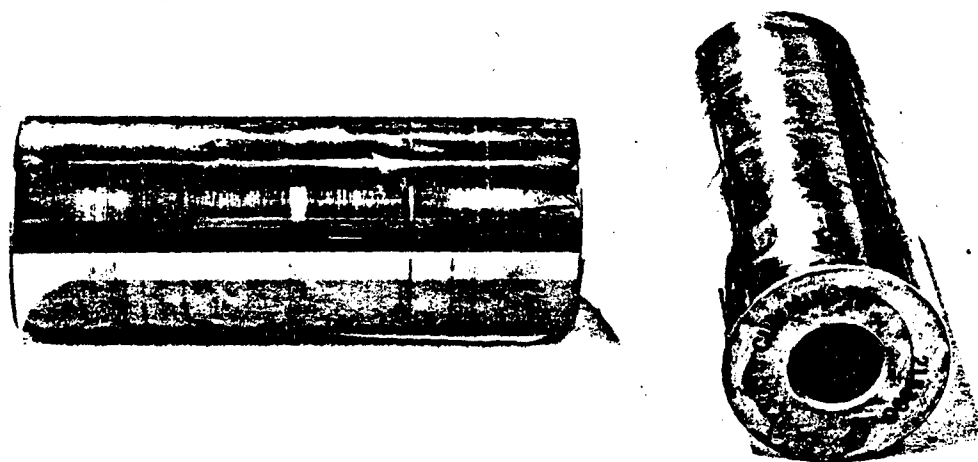
PISTON - TYPICAL BOTTOM SIDE OF
PISTON HEAD



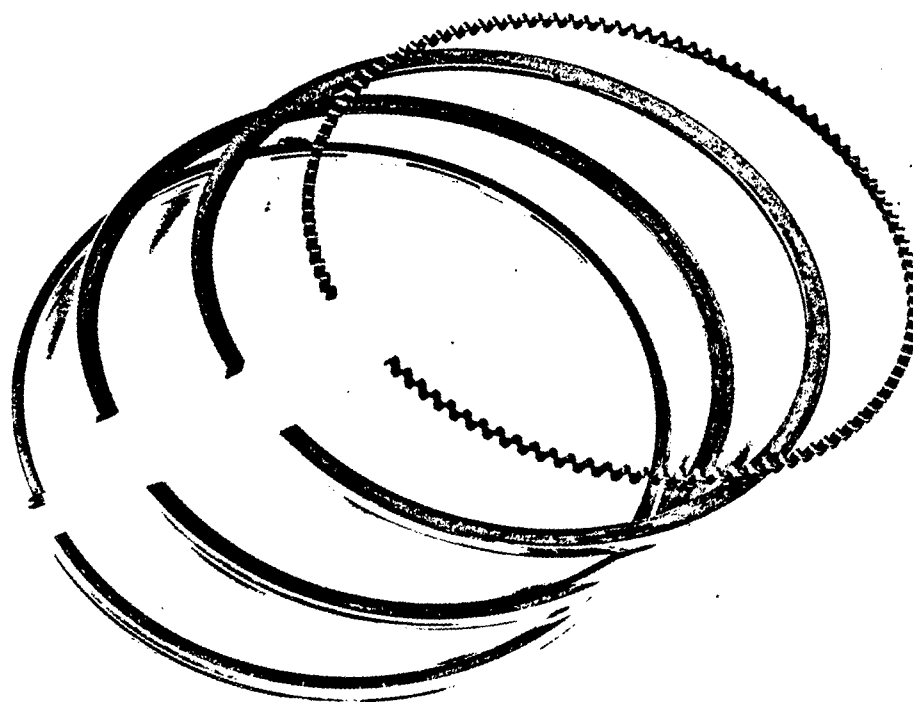
PISTON - SECTIONED TO DISPLAY PIN BORE
CRACKS (WITH DYE PENETRANT)



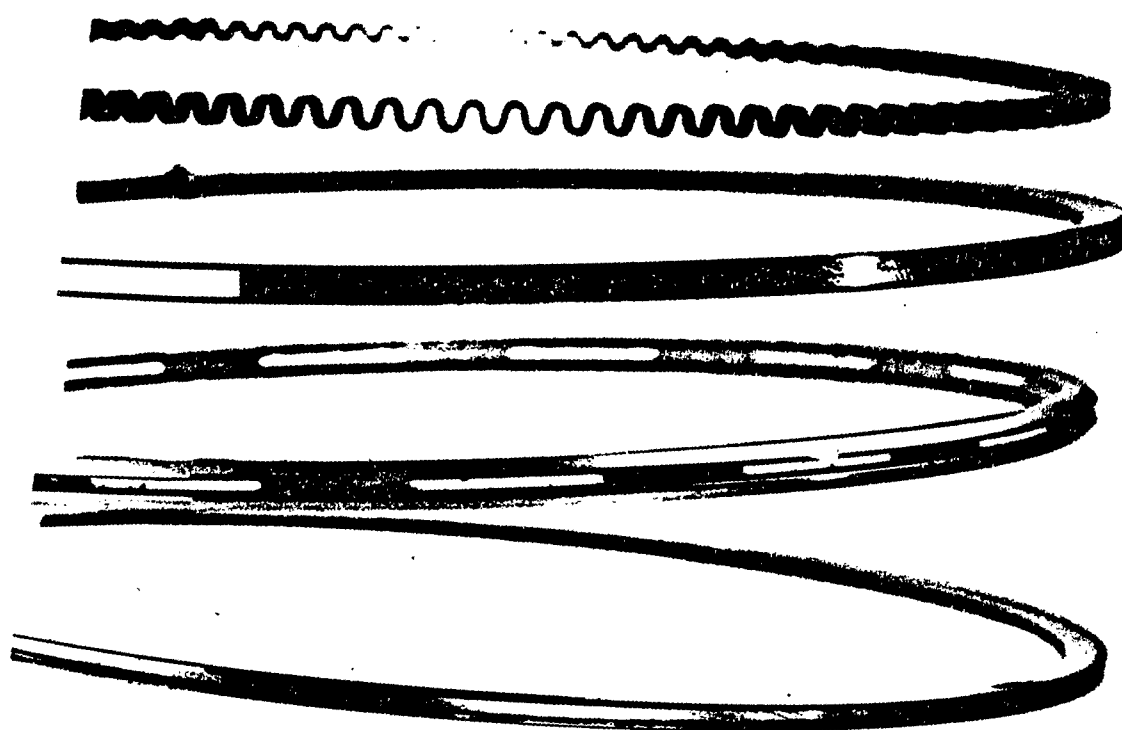
PISTON - SECTIONED TO DISPLAY PIN
BORE CRACKS



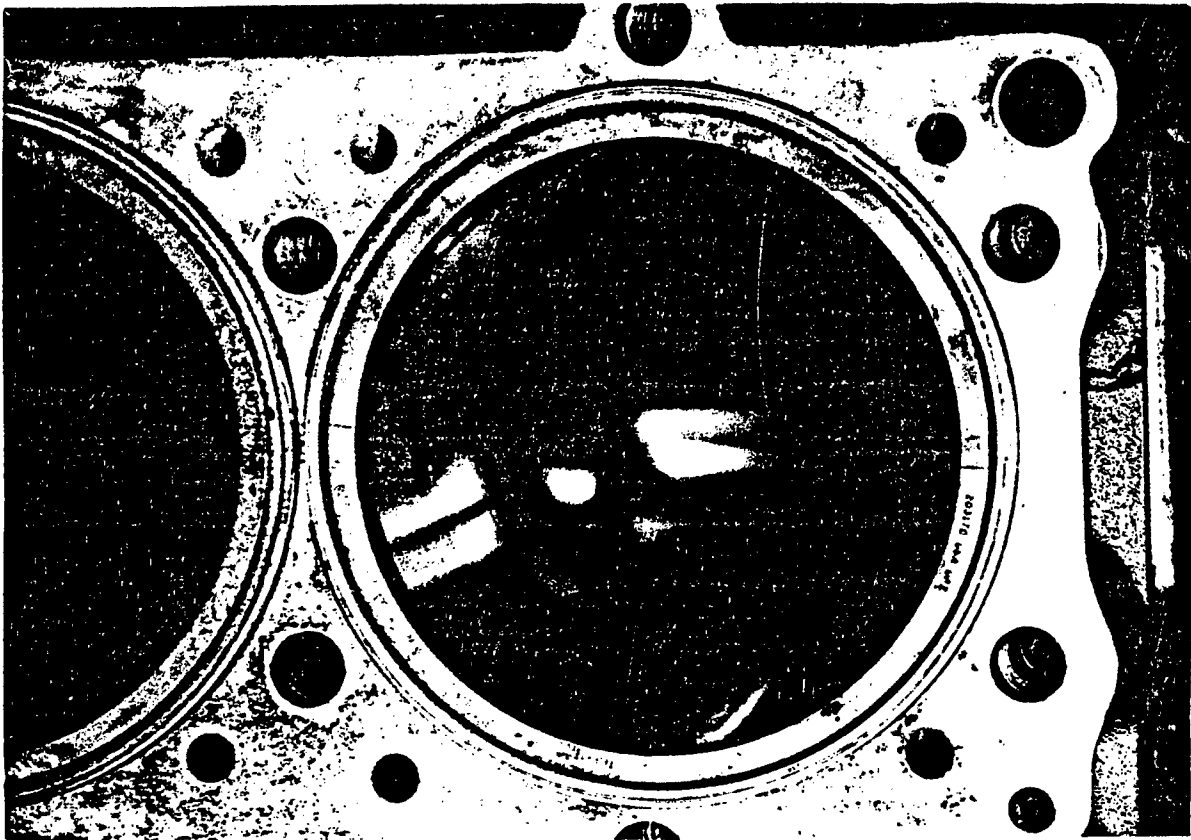
PISTON PIN - TYPICAL APPEARANCE - NO
VISIBLE WEAR



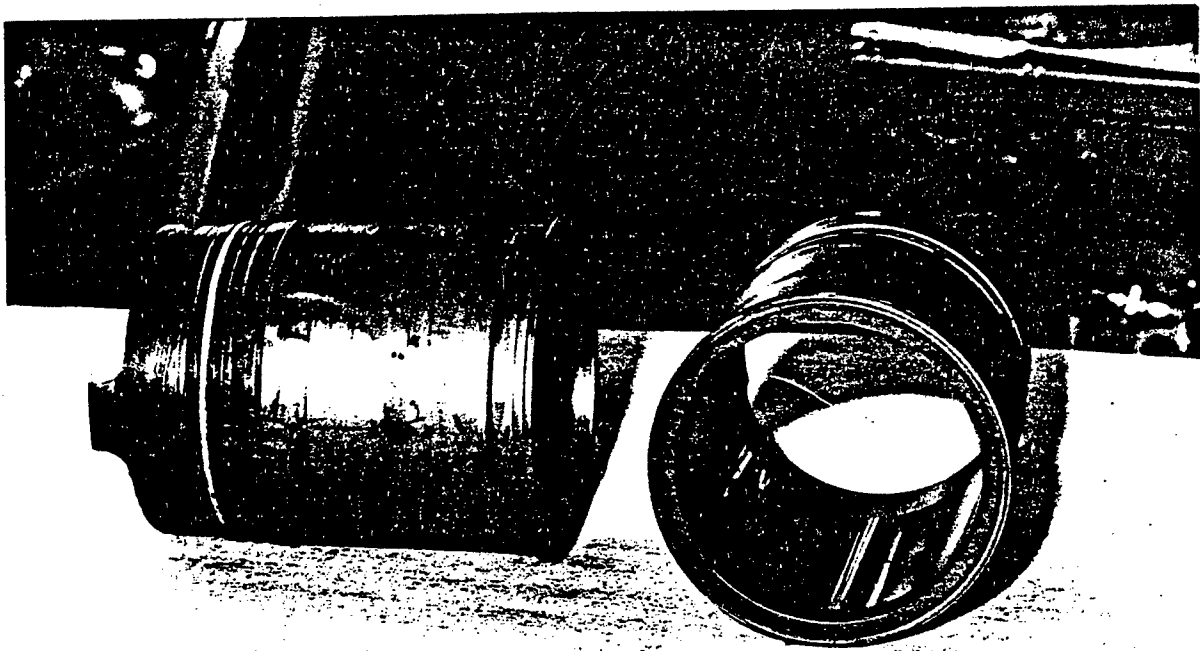
TYPICAL PISTON RINGS - NO BREAKAGE



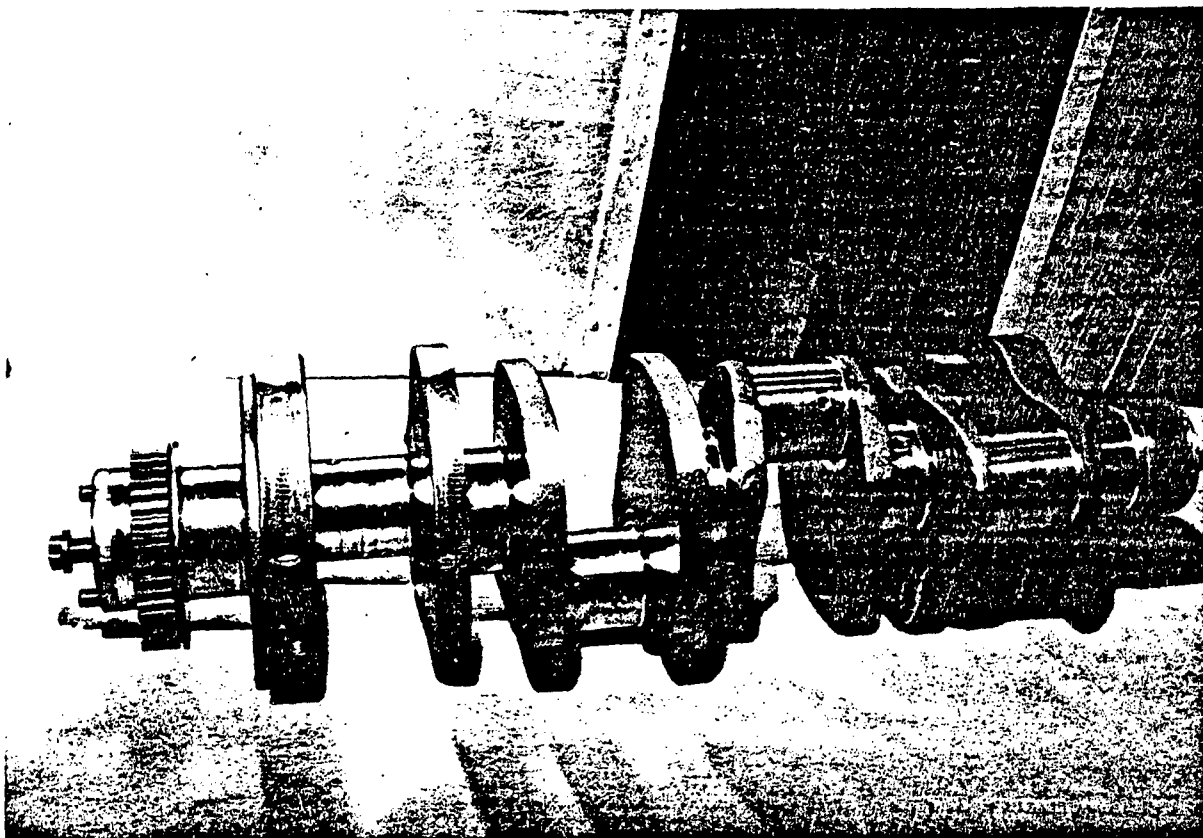
TYPICAL PISTON RINGS - NO SIGNS OF
STRESS



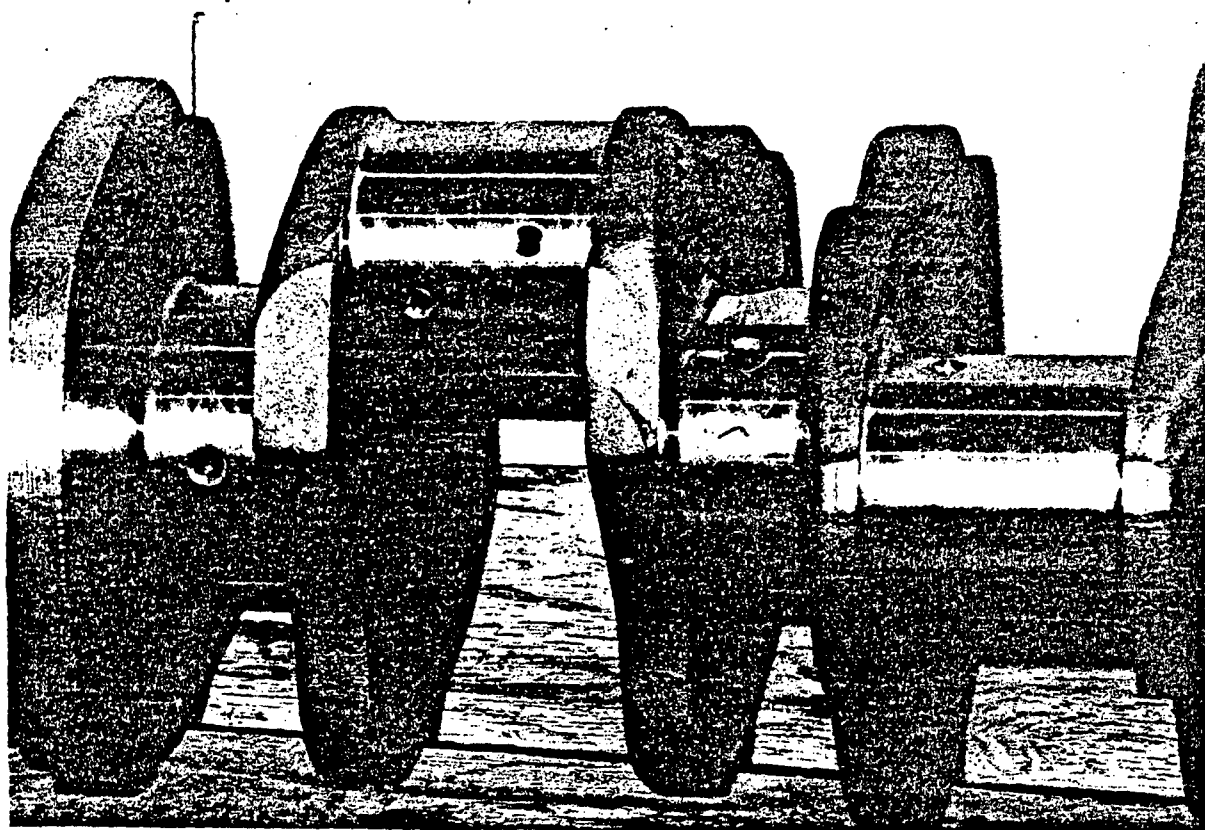
CYLINDER LINERS - EXCELLENT CONDITION



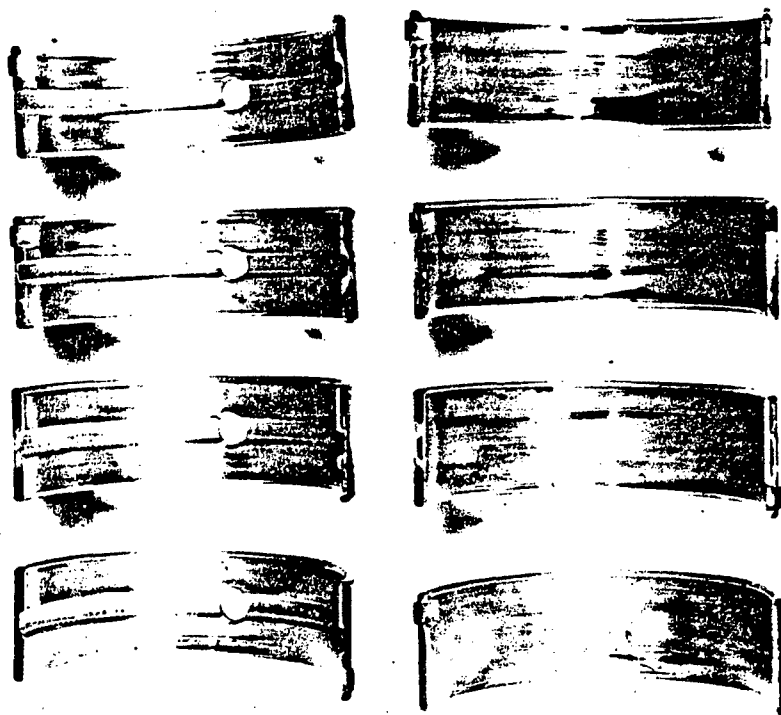
CYLINDER LINERS (REMOVED) - EXCELLENT
CONDITION



CRANKSHAFT - EXCELLENT CONDITION

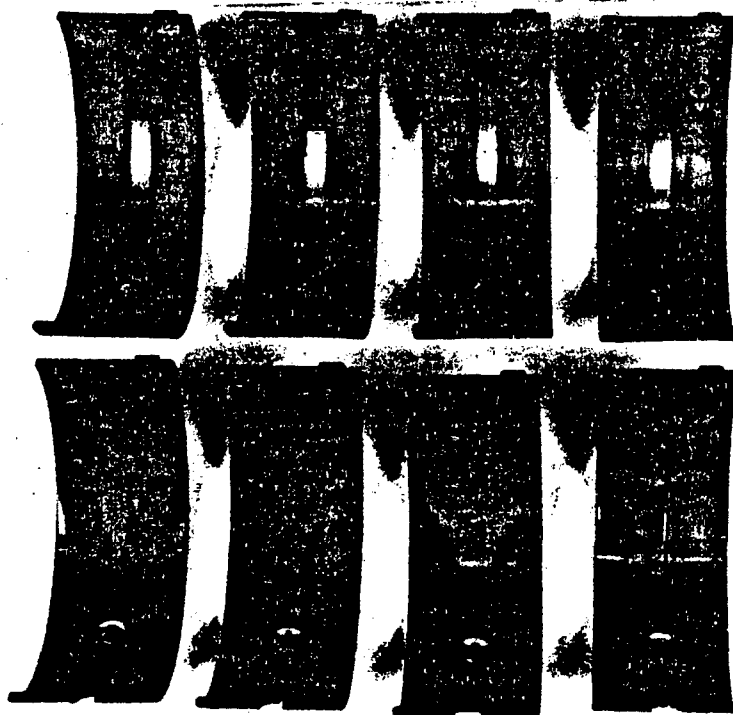


CRANKSHAFT -MAIN AND ROD JOURNALS
EXCELLENT CONDITION



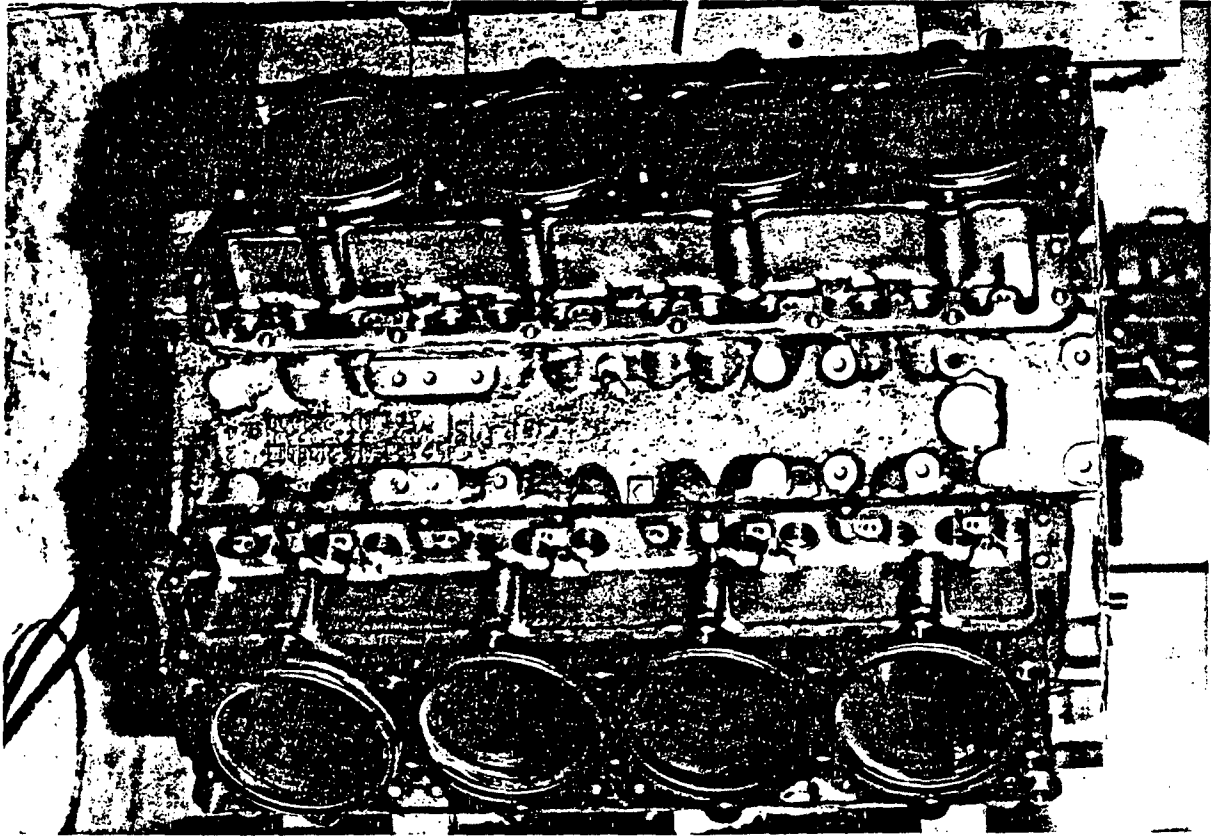
1 2 3 4

MAIN BEARINGS - NO OVERLAY BREAKTHROUGH

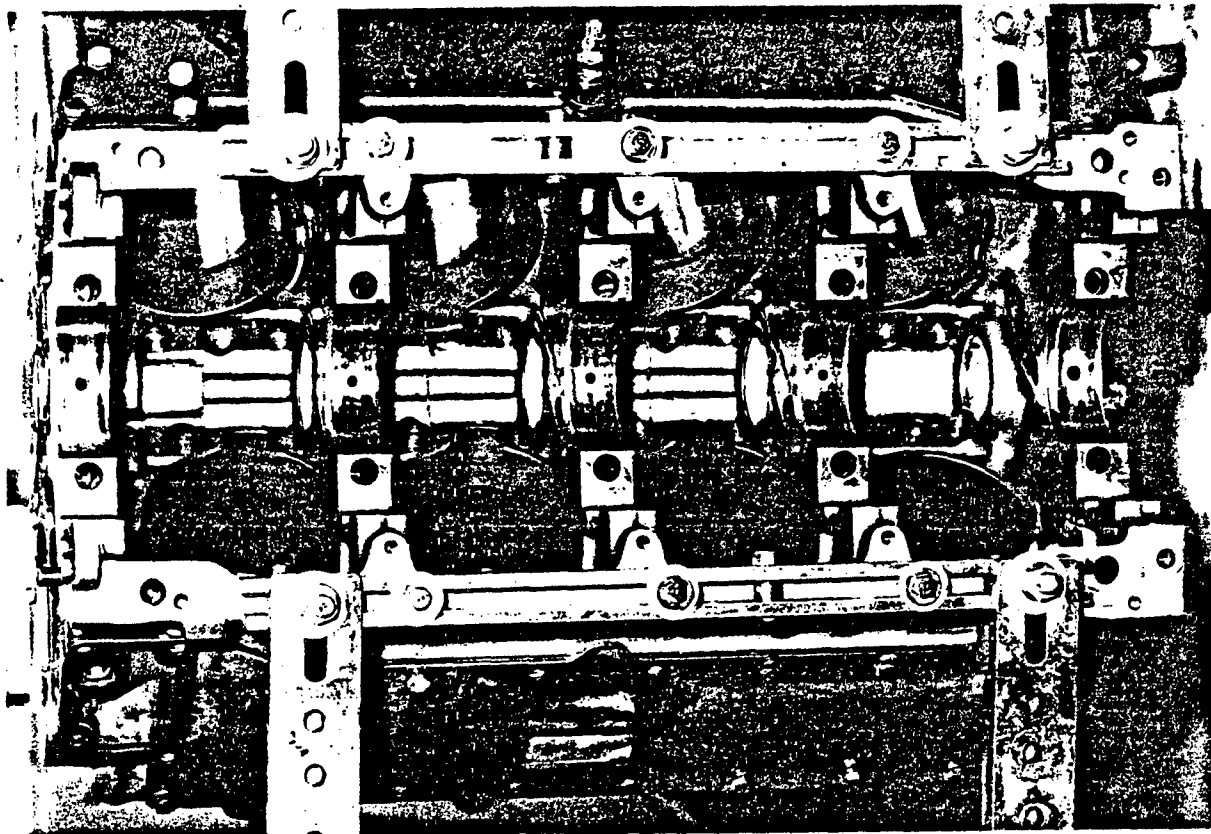


1 2 3 4

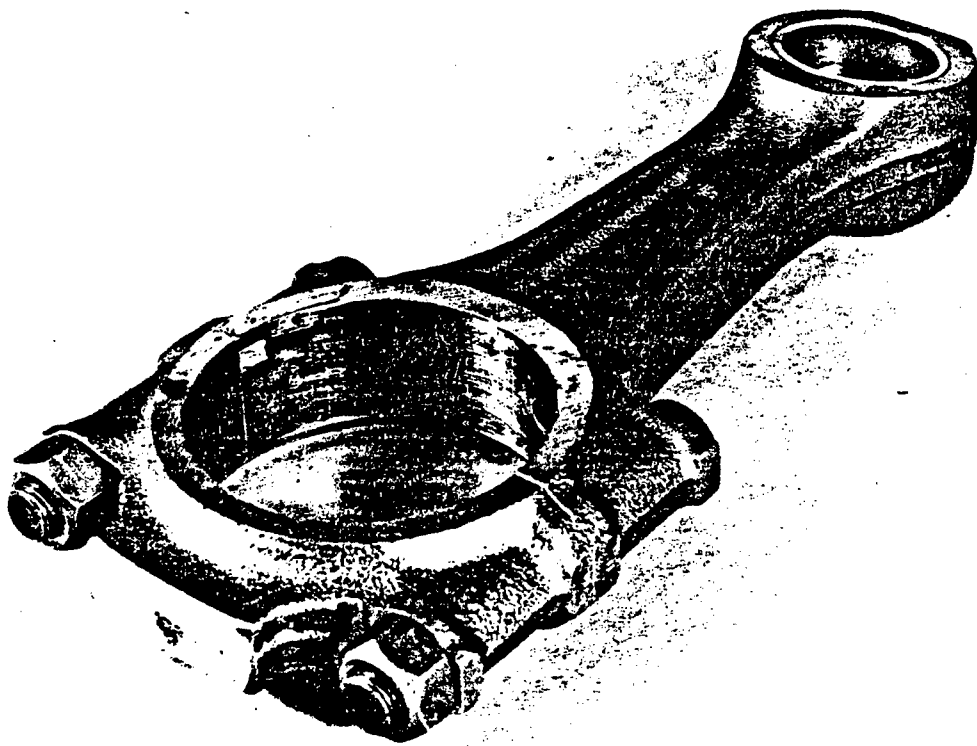
ROD BEARINGS - NO OVERLAY BREAKTHROUGH



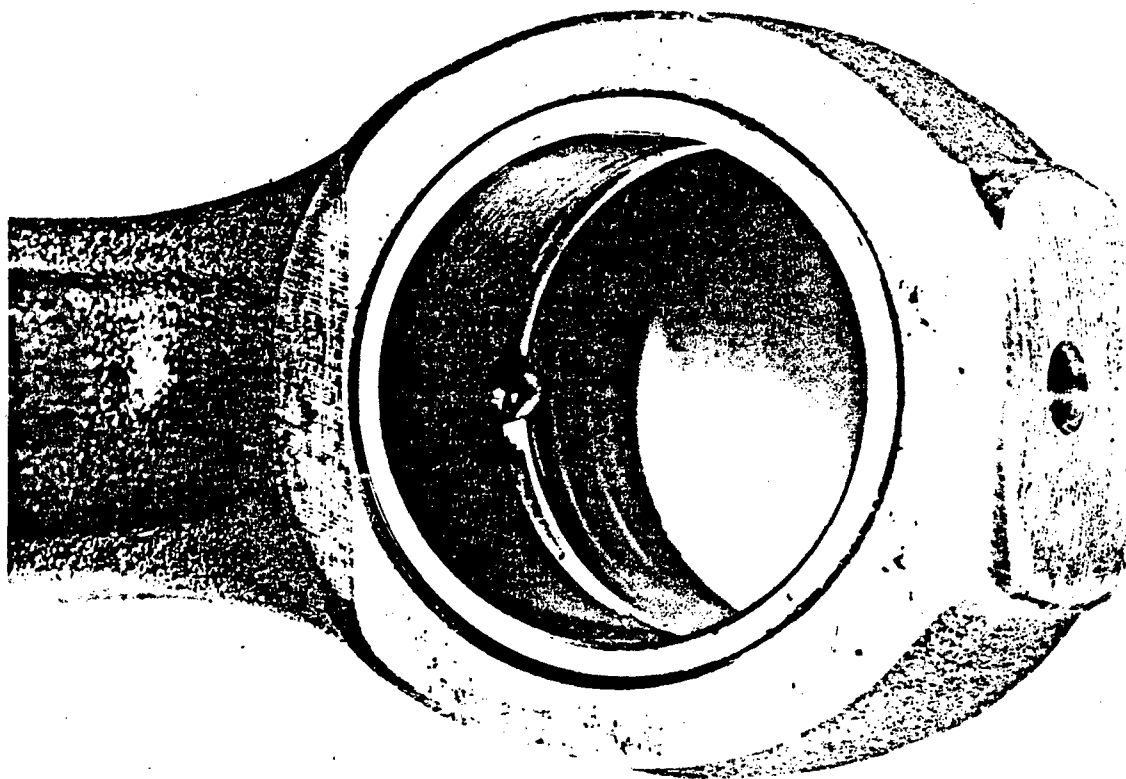
ENGINE BLOCK - TOP VIEW WITH LINERS -
EXCELLENT CONDITION



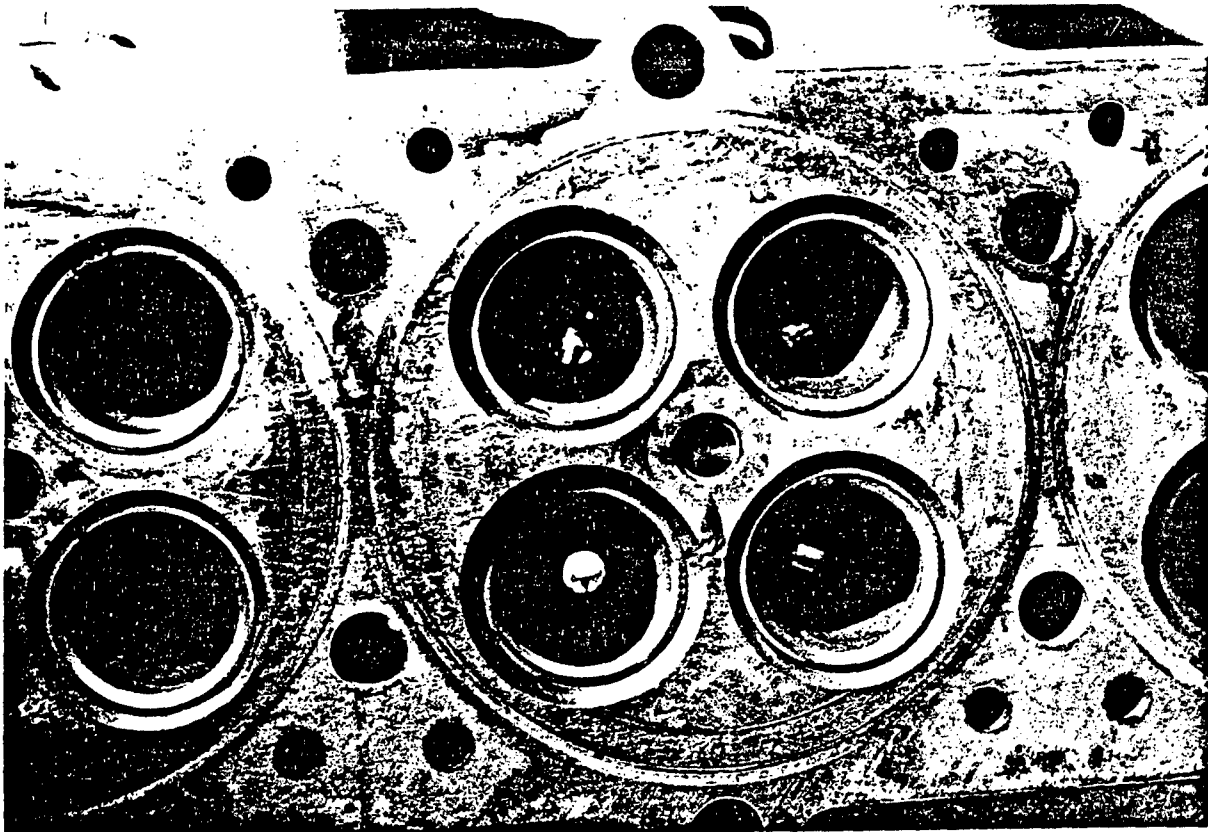
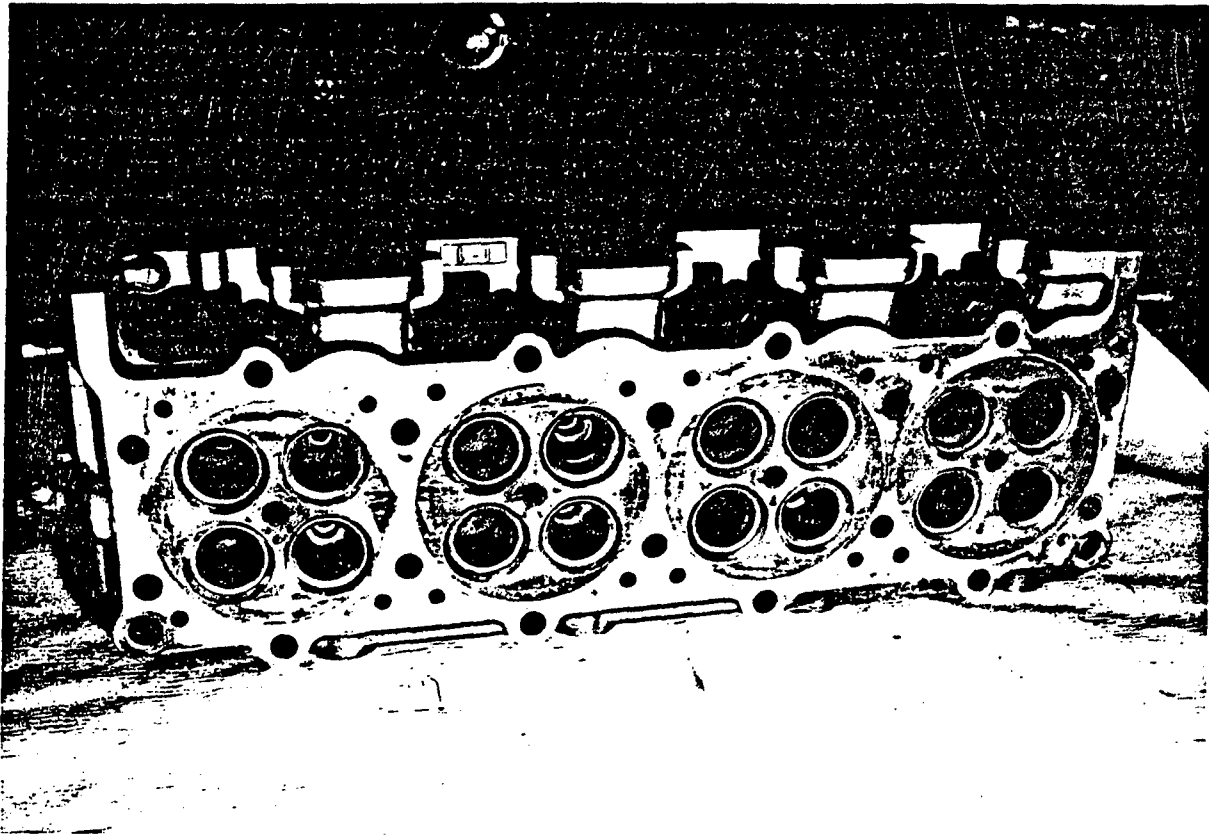
ENGINE BLOCK - BOTTOM VIEW WITH LINERS -
EXCELLENT CONDITIONS



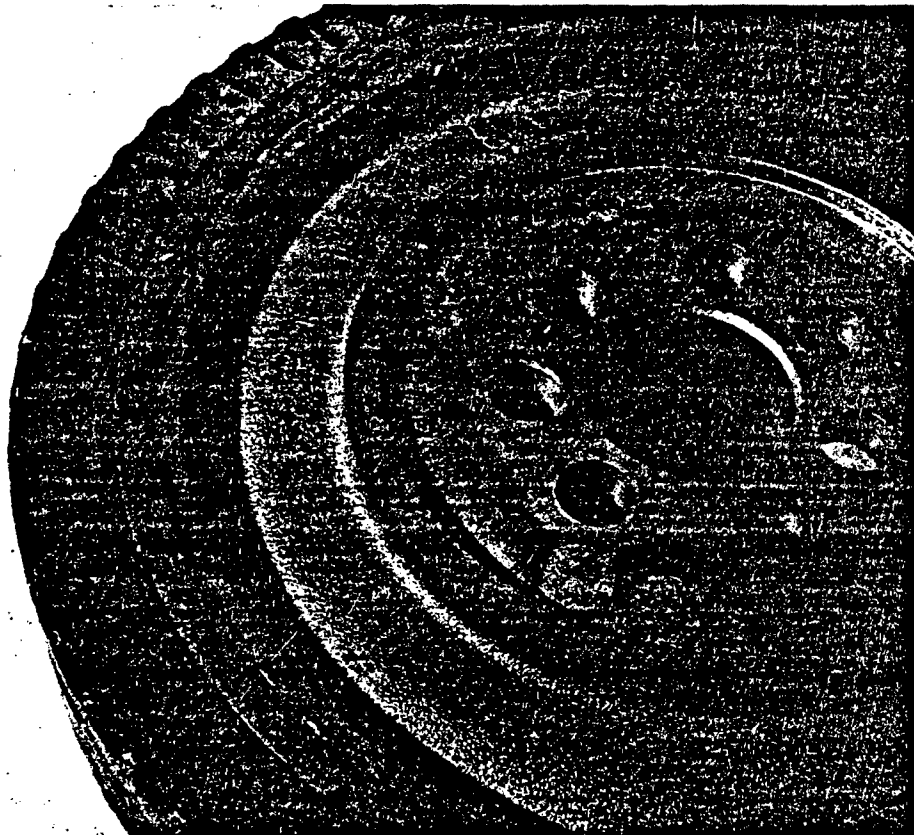
CONNECTING ROD



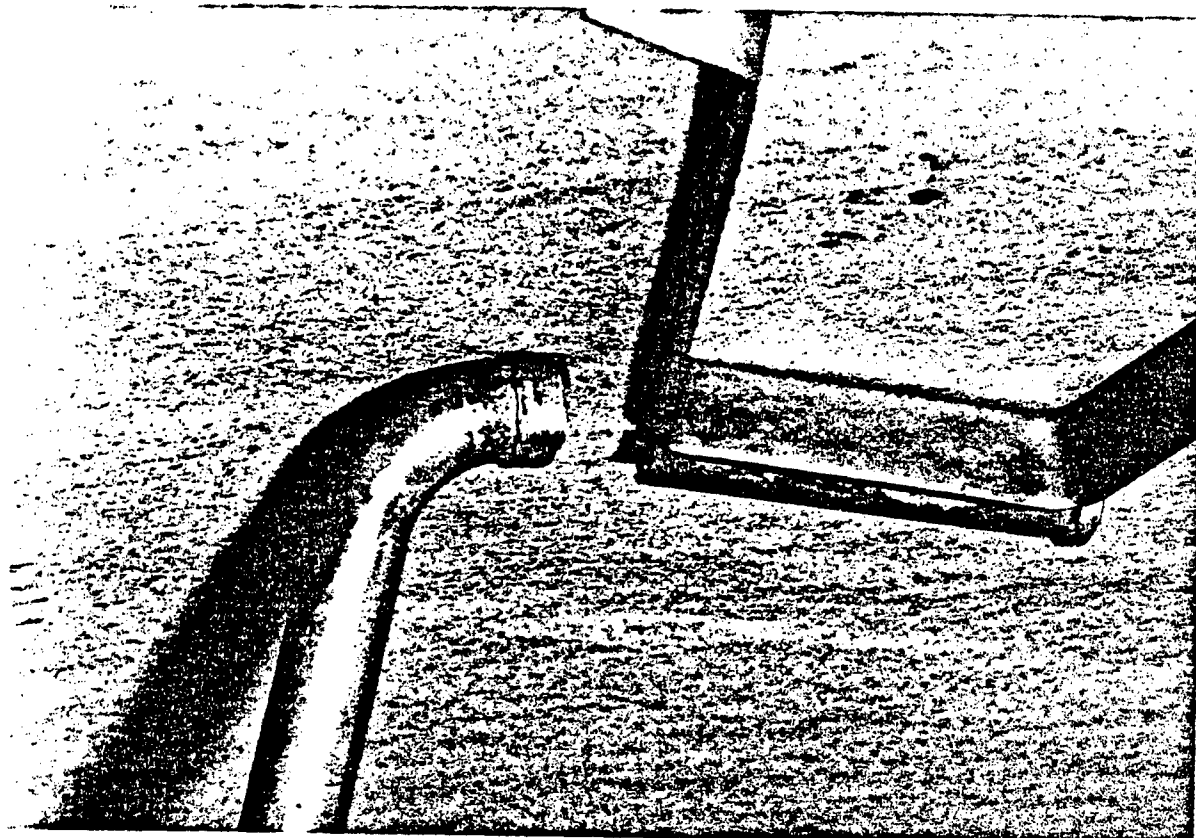
CONNECTING ROD BUSHING - TYPICAL GOOD
APPEARANCE



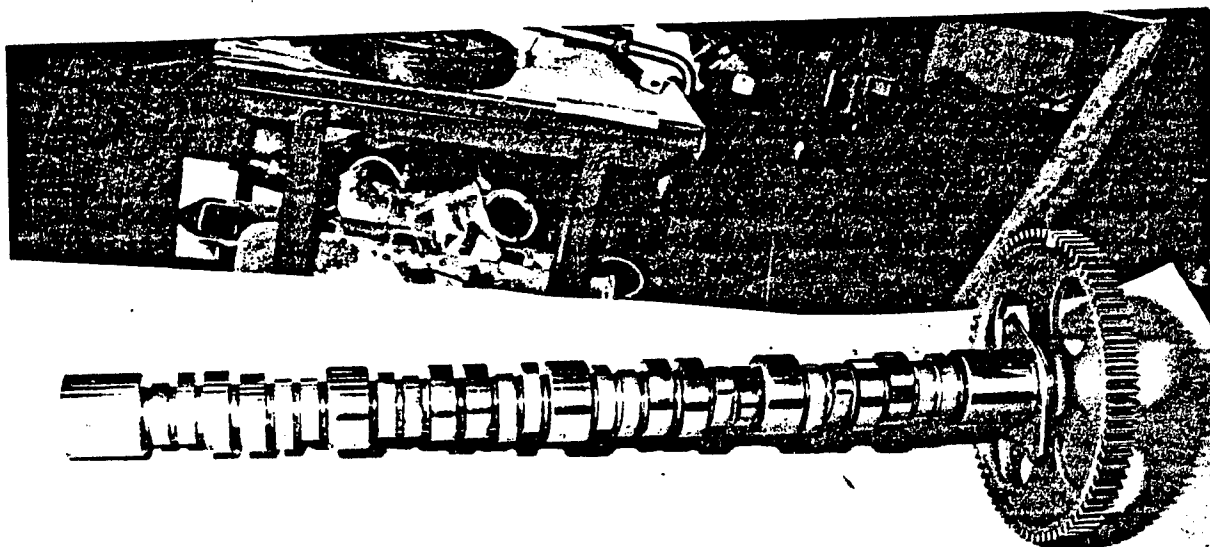
VALVE SEATS - VERY GOOD CONDITION



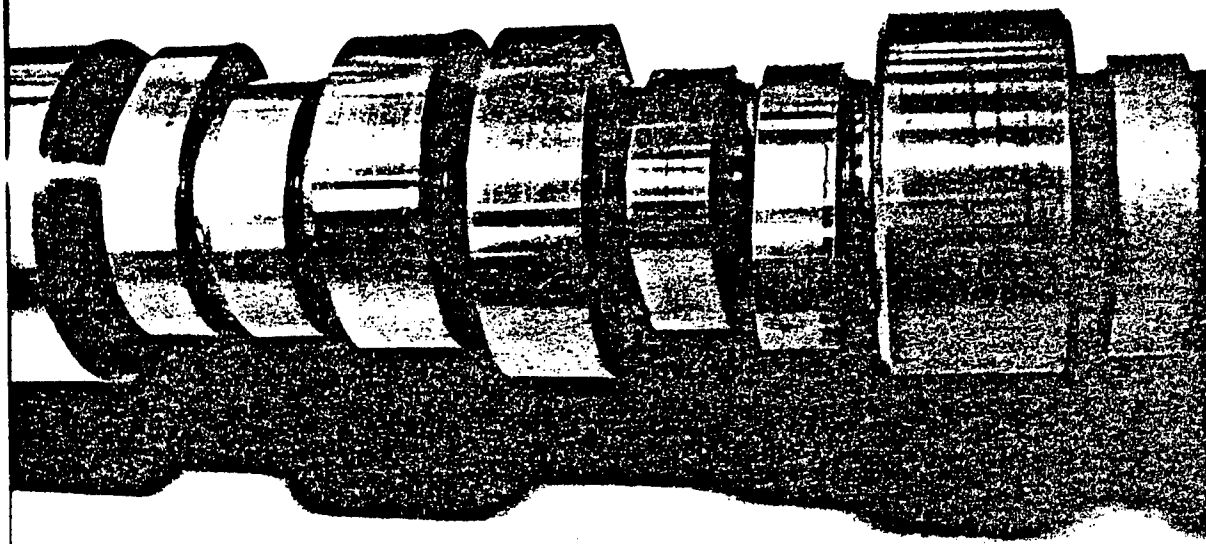
TORSIONAL VIBRATION DAMPER - ELASTOMER
FATIGUE



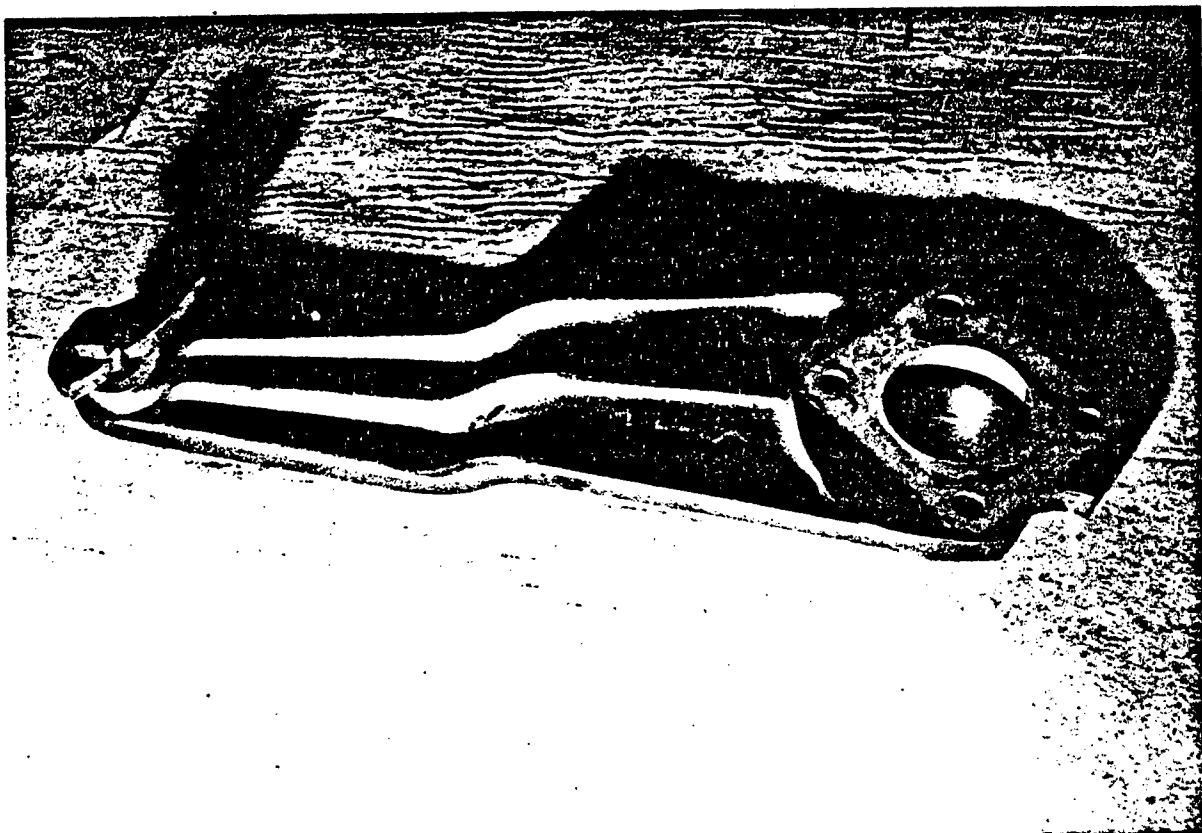
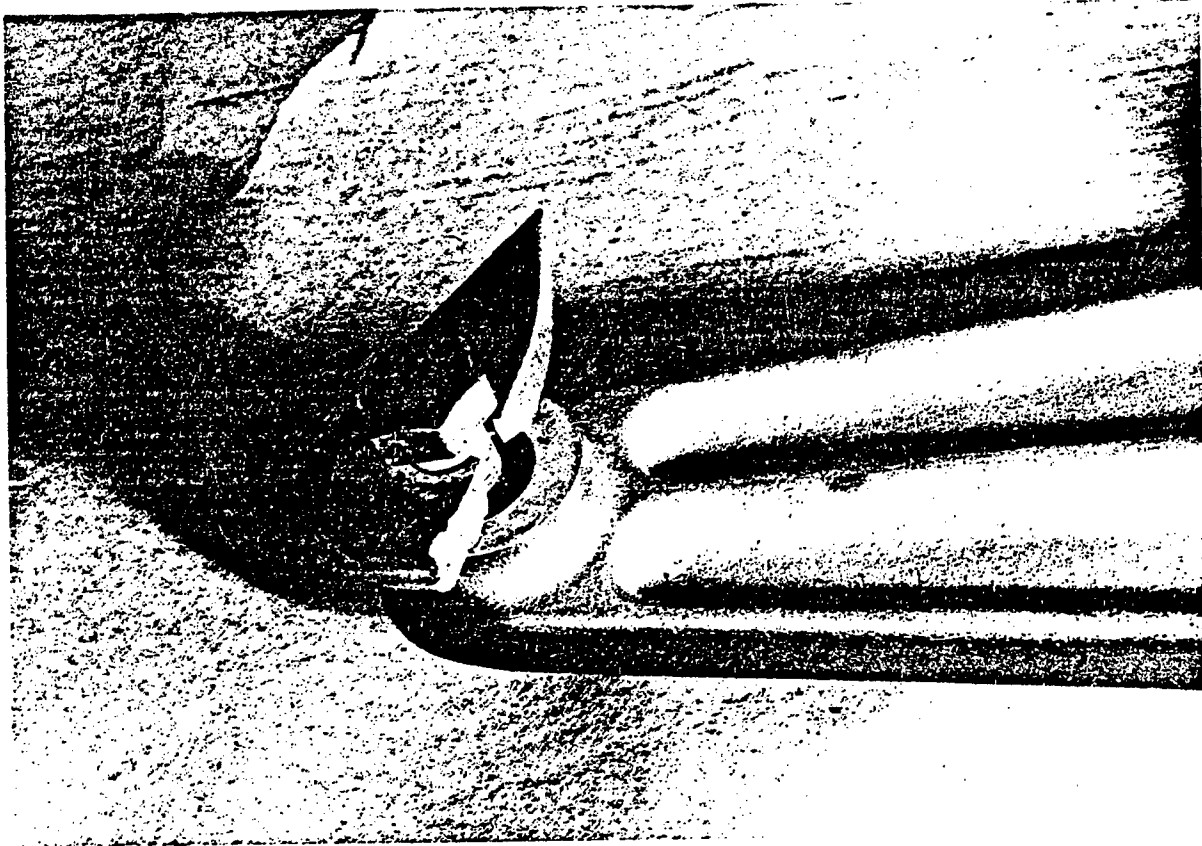
OIL PICKUP TUBE FAILURE



CAMSHAFT - EXCELLENT CONDITION

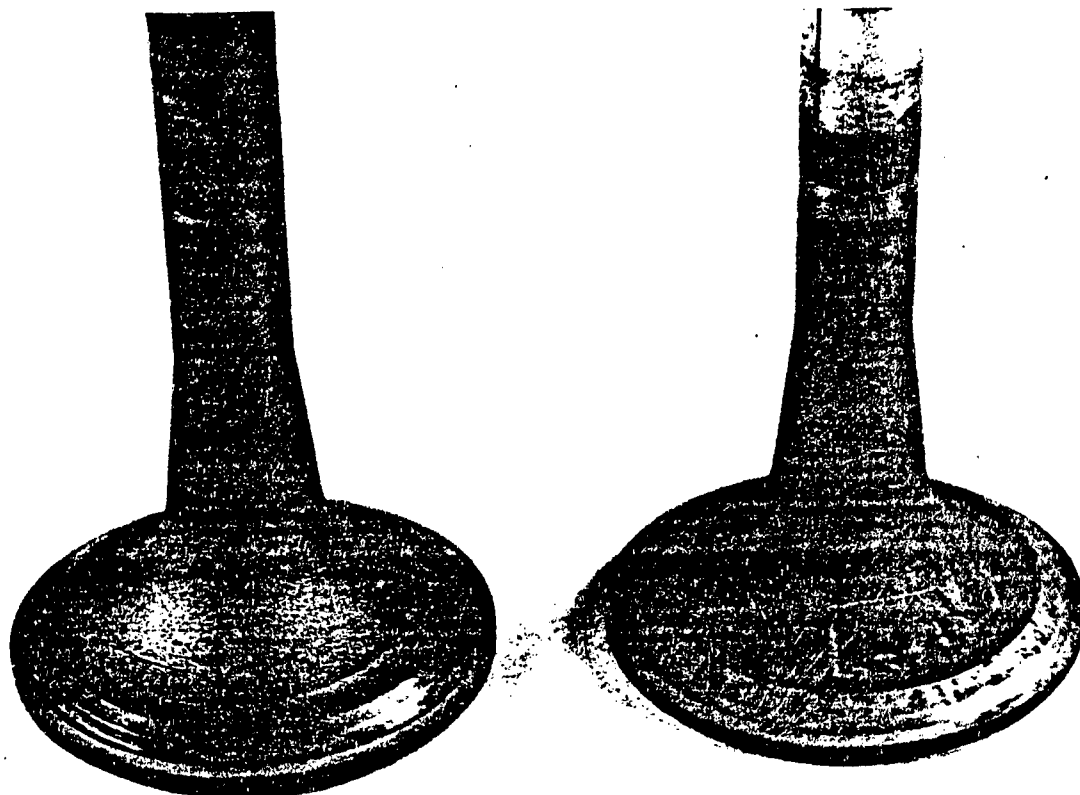


CAMSHAFT - LOBES AND BEARING SURFACES
IN EXCELLENT CONDITION.

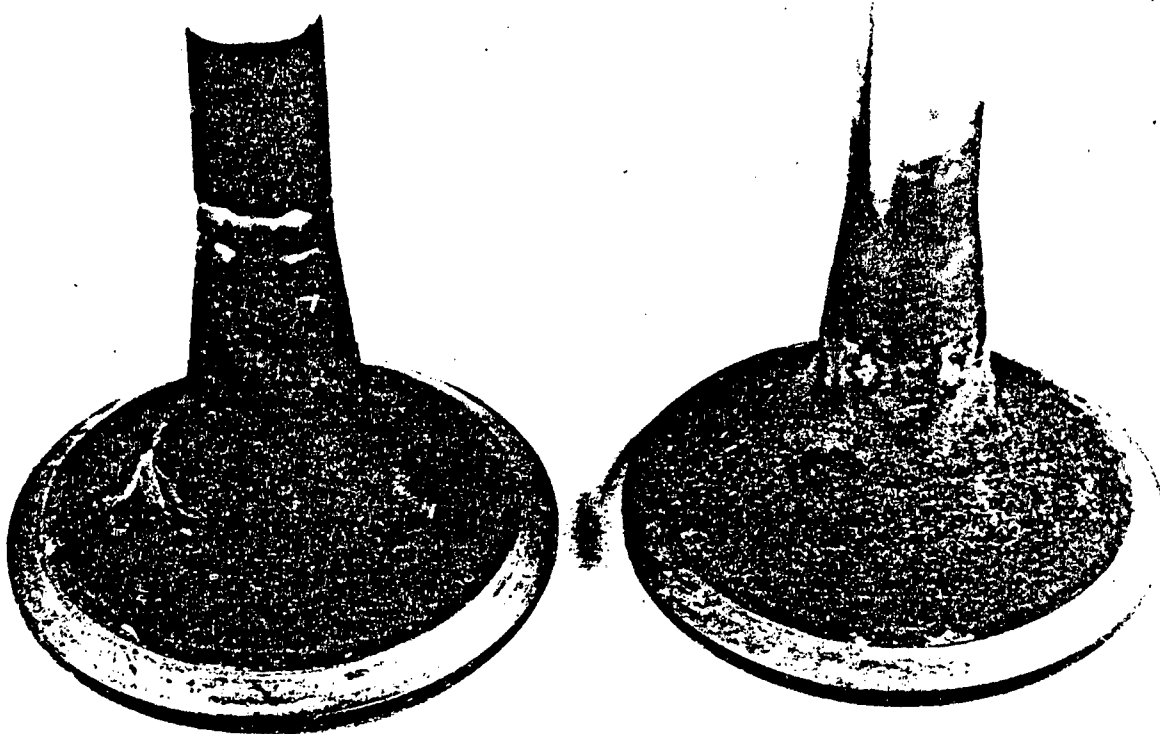


TRANSMISSION OIL COOLER SUPPORT
BRACKET SHOWING BROKEN TAB FROM OIL
COOLER

F-17



TYPICAL INTAKE VALVES - CLEAN - NO
EVIDENCE OF STRESS



TYPICAL EXHAUST VALVES - CLEAN - NO
EVIDENCE OF STRESS

APPENDIX G

DIMENSIONAL INSPECTION SHEETS

PISTON PIN BORE
F-PISTON OD.

DATE
7 Sep 83

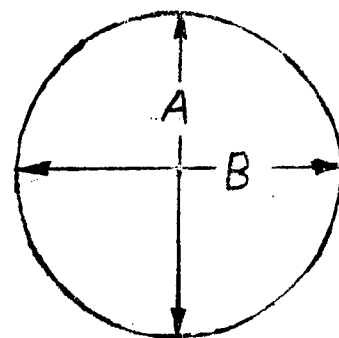
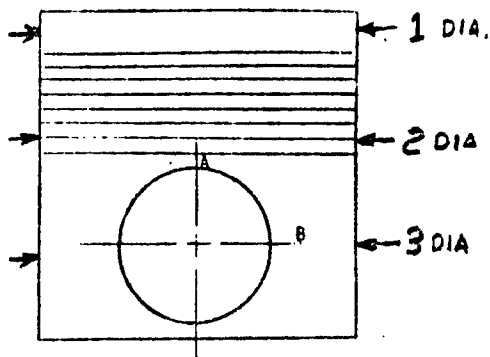
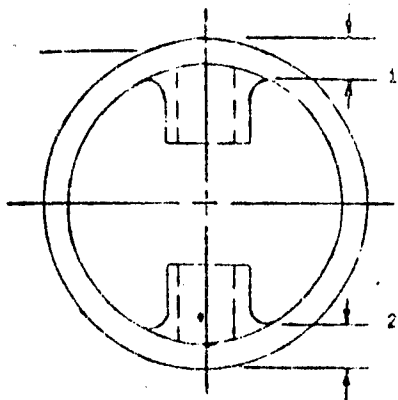
SHEET OF

ENGINE NO.
Cummins VTA-903

WORK ORDER
RZ610133

RECORDED BY
DRSTA-QAA

CHECKED BY
G. GREMBOZ



#	PISTON PIN BORE	TAPER	AVG. DIA	PISTON OD.	1 DIA	2 DIA	3 DIA
1	A1 1.7489	A2 1.7489	0		A 5.443	A 5.468	A 5.483
	B1 1.7490	B2 1.7491	.0001		B 5.444	B 5.471	B 5.481
	OR .0001	OR .0002	1.7490		OR .001	OR .003	OR .002
2	A1 1.7495	A2 1.7495	0		A 5.448	A 5.470	A 5.484
	B1 1.7498	B2 1.7498	0		B 5.449	B 5.470	B 5.483
	OR .0003	OR .0003	1.7496		OR .001	OR .000	OR .001
3	A1 1.7494	A2 1.7496	.0002		A 5.449	A 5.468	A 5.485
	B1 1.7496	B2 1.7500	.0004		B 5.450	B 5.470	B 5.483
	OR .0002	OR .0004	1.7498		OR .001	OR .002	OR .002
4	A1 1.7491	A2 1.7491	0		A 5.448	A 5.467	A 5.484
	B1 1.7492	B2 1.7492	0		B 5.450	B 5.469	B 5.483
	OR .0001	OR .0001	1.7492		OR .002	OR .002	OR .001
5	A1 1.7491	A2 1.7491	0		A 5.448	A 5.470	A 5.483
	B1 1.7491	B2 1.7491	0		B 5.448	B 5.469	B 5.483
	OR .0000	OR .0000	1.7491		OR .000	OR .001	OR .000
6	A1 1.7494	A2 1.7494	0		A 5.447	A 5.468	A 5.480
	B1 1.7494	B2 1.7495	.0001		B 5.453	B 5.471	B 5.484
	OR .0000	OR .0001	1.7494		OR .006	OR .003	OR .004
7	A1 1.7492	A2 1.7492	0		A 5.448	A 5.468	A 5.484
	B1 1.7494	B2 1.7494	0		B 5.449	B 5.469	B 5.482
	OR .0002	OR .0002	1.7493		OR .001	OR .001	OR .002
8	A1 1.7492	A2 1.7492	0		A 5.444	A 5.464	A 5.484
	B1 1.7492	B2 1.7494	.0002		B 5.444	B 5.467	B 5.483
	OR .0000	OR .0002	1.7493		OR .000	OR .003	OR .001

NOTE: Pistons numbered 2, 3, 4, 5, 6 and 7 show visual signs of cracks in the upper half of the wrist pin bores. A liquid penetrant inspection performed gives a relative indication of the discontinuities present in the above described pistons.

G. Grembos 9/7/83



CONNECTING ROD BEARING SHELL THICKNESS

DATE

12 Sep 83

SHEET OF

ENGINE NO.

Cummins VTA-903

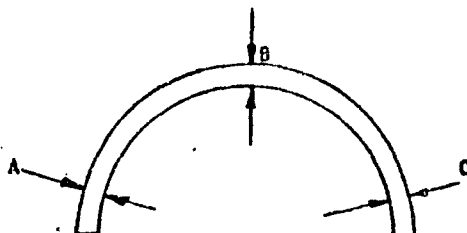
WORK ORDER

RECORDED BY

DRSTA-QAA

CHECKED BY

D. Melanshek



CONN. ROD NO.	UPPER HALF					CONN. ROD NO.	LOWER HALF				
	LOC.	FRONT	REAR	TAPER	WEAR		LOC.	FRONT	REAR	TAPER	WEAR
1	A	.0938	.0937	.0001			A	.0935	.0937	.0002	
	B	.0935	.0931	.0004			B	.0941	.0941	.0000	
	C	.0940	.0940	.0000			C	.0932	.0935	.0003	
2	A	.0938	.0938	.0000			A	.0933	.0935	.0002	
	B	.0932	.0932	.0000			B	.0940	.0942	.0002	
	C	.0934	.0937	.0003			C	.0938	.0938	.0000	
3	A	.0935	.0935	.0000			A	.0935	.0935	.0000	
	B	.0935	.0935	.0000			B	.0940	.0940	.0000	
	C	.0935	.0935	.0000			C	.0938	.0940	.0002	
4	A	.0938	.0938	.0000			A	.0935	.0935	.0000	
	B	.0933	.0935	.0002			B	.0940	.0940	.0000	
	C	.0935	.0937	.0002			C	.0938	.0938	.0000	
5	A	.0937	.0938	.0001			A	.0938	.0935	.0003	
	B	.0932	.0935	.0003			B	.0942	.0942	.0000	
	C	.0940	.0938	.0002			C	.0935	.0935	.0000	
6	A	.0930	.0930	.0000			A	.0935	.0940	.0005	
	B	.0932	.0932	.0000			B	.0940	.0940	.0000	
	C	.0934	.0935	.0001			C	.0936	.0936	.0000	

REMARKS:



021

9-20-83

CONNECTING ROD BEARING SHELL THICKNESS

DATE
12 Sep 83

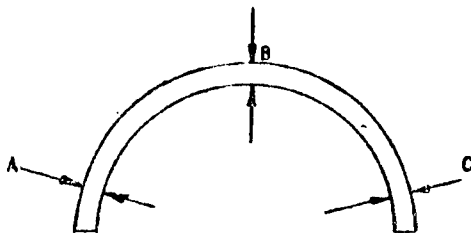
SHEET 1 OF 1

ENGINE NO.
Cummins VTA-903

WORK ORDER

RECORDED BY
DRSTA-QAA

CHECKED BY
D. Melanshek



CONN. ROD NO.	UPPER HALF					CONN. ROD NO.	LOWER HALF				
	LOC.	FRONT	REAR	TAPER	WEAR		LOC.	FRONT	REAR	TAPER	WEAR
7	A	.0935	.0935	.0000		7	A	.0935	.0935	.0000	
	B	.0934	.0934	.0000			B	.0942	.0942	.0000	
	C	.0940	.0940	.0000			C	.0938	.0938	.0000	
8	A	.0937	.0935	.0002		8	A	.0935	.0937	.0002	
	B	.0942	.0942	.0000			B	.0935	.0935	.0000	
	C	.0940	.0940	.0000			C	.0935	.0938	.0003	
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				



D. Mel.

9-20-83

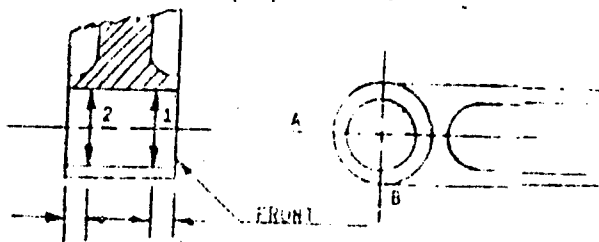
G-4

CONNECTING ROD

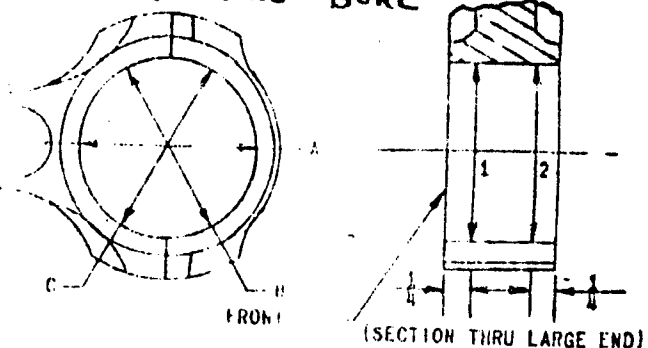
PIN BORE & BEARING BORE

DATE 10 Sep 83
ENGINE NO. Cummins VTA-903
RECORDED BY DRSTA-QAA
SHEET OF
WORK ORDER RZ610133
CHECKED BY D. Melanshek

PIN BORE



BEARING BORE



CYL.	LOC.	PIN BORE POSITION				CYL.	LOC.	BEARING BORE POSITION			
		1	2	TAPER	AVG. DIA.			1	2	TAPER	AVG. DIA.
1	A	1.7512	1.7512	.0000	1.7512		A	3.3174	3.3174	.0000	
	B	1.7510	1.7512	.0002	1.7511		B	3.3170	3.3170	.0000	
	OR	.0002	.0000	.0002			C	3.3168	3.3172	.0004	
2	A	1.7516	1.7516	.0000	1.7516		OR	.0006	.0004	.0002	
	B	1.7514	1.7516	.0002	1.7515		A	3.3172	3.3174	.0002	
	OR	.0002	.0000	.0002			B	3.3174	3.3170	.0004	
3	A	1.7510	1.7510	.0000	1.7510		C	3.3170	3.3174	.0004	
	B	1.7510	1.7510	.0000	1.7510		OR	.0004	.0004	.0000	
	OR	.0000	.0000	.0000			A	3.3172	3.3174	.0002	
4	A	1.7510	1.7510	.0000	1.7510		B	3.3174	3.3176	.0002	
	B	1.7510	1.7510	.0000	1.7510		C	3.3170	3.3172	.0002	
	OR	.0000	.0000	.0000			OR	.0004	.0004	.0000	
5	A	1.7510	1.7510	.0000	1.7510		A	3.3172	3.3174	.0002	
	B	1.7510	1.7510	.0000	1.7510		B	3.3172	3.3177	.0005	
	OR	.0000	.0000	.0000			C	3.3172	3.3174	.0002	
6	A	1.7510	1.7512	.0002	1.7511		OR	.0004	.0004	.0000	
	B	1.7510	1.7516	.0006	1.7513		A	3.3172	3.3174	.0002	
	OR	.0000	.0004	.0004			B	3.3172	3.3177	.0005	
7	A	1.7516	1.7512	.0004	1.7514		C	3.3172	3.3174	.0002	
	B	1.7512	1.7512	.0000	1.7512		OR	.0000	.0003	.0003	
	OR	.0004	.0000	.0004			A	3.3172	3.3170	.0007	
8	A	1.7512	1.7510	.0002	1.7511		B	3.3176	3.3172	.0004	
	B	1.7512	1.7512	.0000	1.7512		C	3.3170	3.3174	.0004	
	OR	.0000	.0002	.0002			OR	.0006	.0004	.0002	
9	A	1.7512	1.7514	.0002	1.7513		A	3.3170	3.3172	.0002	
	B	1.7512	1.7512	.0000	1.7512		B	3.3169	3.3170	.0001	
	OR	.0000	.0002	.0002			C	3.3171	3.3173	.0002	
10	A	1.7512	1.7514	.0002	1.7513		OR	.0002	.0003	.0001	
	B	1.7512	1.7512	.0000	1.7512		A	3.3174	3.3174	.0000	
	OR	.0000	.0002	.0002			B	3.3170	3.3174	.0004	
11	A	1.7512	1.7514	.0002	1.7513		C	3.3168	3.3170	.0002	
	B	1.7512	1.7512	.0000	1.7512		OR	.0006	.0004	.0002	
	OR	.0000	.0002	.0002			A	3.3178	3.3174	.0004	
12	A	1.7512	1.7514	.0002	1.7513		B	3.3170	3.3164	.0006	
	B	1.7512	1.7512	.0000	1.7512		C	3.3172	3.3172	.0000	
	OR	.0000	.0002	.0002			OR	.0008	.0010	.0002	

CONNECTING ROD BEARINGS

9 Sep 83

SHEET

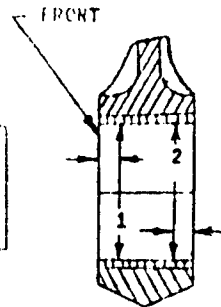
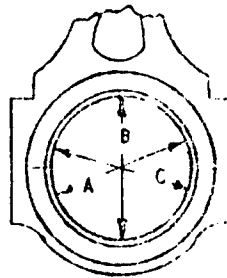
OF

ENGINE NO.
Cummins VTA-908

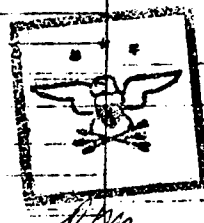
LWO NO.
RZ610133

RECORDED BY
DRSTA-QAA

CHECKED BY
D. Melanshek



BEARING	SPEC. BEARING I.D.				BEARING	SPEC. BEARING I.D.			
	1	2	TAPER	AVG. DIA.		1	2	TAPER	AVG. DIA.
1	A	3.1296	3.1296	.0000		A			---
	B	3.1301	3.1306	.0005		B			
	C	3.1299	3.1302	.0003		C			
	OR	.0005	.0010	.0005		OR			
2	A	3.1291	3.1292	.0001		A			---
	B	3.1296	3.1300	.0004		B			
	C	3.1297	3.1300	.0003		C			
	OR	.0006	.0008	.0002		OR			
3	A	3.1298	3.1296	.0002		A			---
	B	3.1298	3.1298	.0000		B			
	C	3.1294	3.1294	.0000		C			
	OR	.0004	.0004	.0000		OR			
4	A	3.1297	3.1294	.0003		A			---
	B	3.1301	3.1299	.0002		B			
	C	3.1301	3.1299	.0002		C			
	OR	.0004	.0005	.0001		OR			
5	A	3.1294	3.1294	.0000		A			---
	B	3.1299	3.1304	.0005		B			
	C	3.1299	3.1302	.0003		C			
	OR	.0005	.0010	.0005		OR			
6	A	3.1292	3.1296	.0004		A			---
	B	3.1298	3.1302	.0004		B			
	C	3.1300	3.1302	.0002		C			
	OR	.0008	.0008	.0000		OR			
7	A	3.1290	3.1292	.0002		A			---
	B	3.1296	3.1298	.0002		B			
	C	3.1294	3.1298	.0004		C			
	OR	.0006	.0006	.0000		OR			
8	A	3.1290	3.1292	.0002		A			---
	B	3.1296	3.1298	.0002		B			
	C	3.1290	3.1294	.0004		C			
	OR	.0006	.0006	.0000		OR			
	A					A			---
	B					B			
	C					C			
	OR					OR			
	A					A			---
	B					B			
	C					C			
	OR					OR			



THRUST BEARING

DATE

12 Sep 83

SHEET

OF

ENGINE NO.

Cummins VTA-903

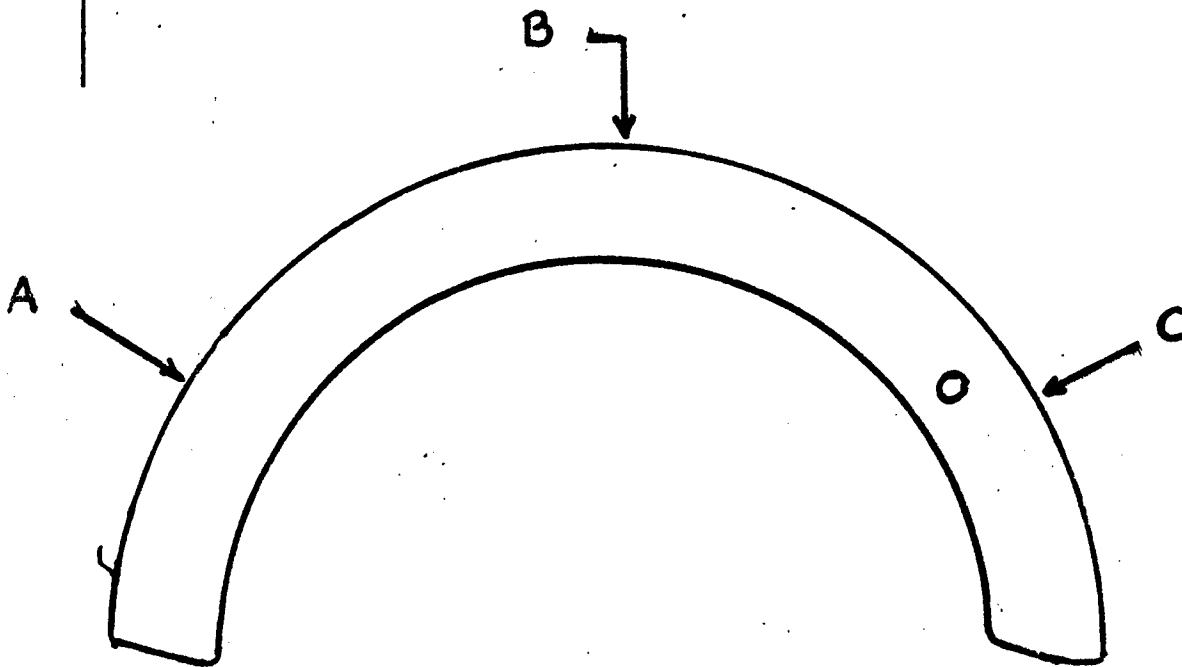
WORK ORDER

RECORDED BY

DRSTA-QAA

CHECKED BY

D. Melanshek



BEARG. NO.	THICK. A	THICK. B	THICK. C
UPPER REAR	.1480	.1510	.1490
LOWER REAR	.1490	.1515	.1500
UPPER FRONT	.1500	.1515	.1500
LOWER FRONT	.1495	.1513	.1498



D.M.
9-16-83

PISTON PIN DIMENSION CHECK
(LAB. SOP.)

DATE
8 Sep 83

SHEET OF

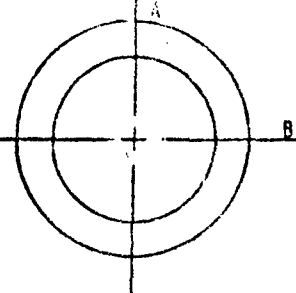
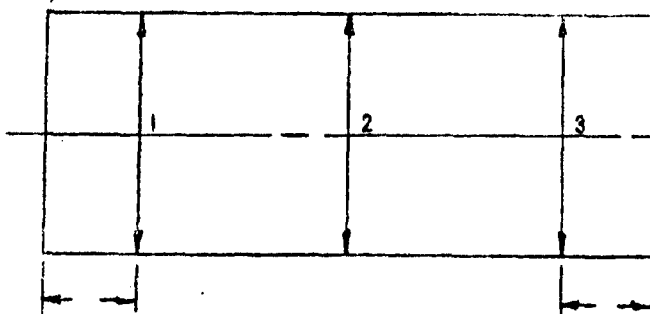
ENGINE NO.
Cummins VTA-903

WORK ORDER
RZ610133

RECORDED BY
DRSTA-QAA

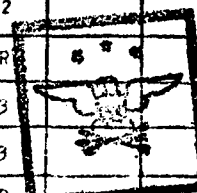
CHECKED BY
G. Grembos

FRONT



CYL. NO.	LOC.	POSITION			TAPER	AVG. WEAR	CYL. NO.	LOC.	POSITION			TAPER	AVG. WEAR
		1	2	3					1	2	3		
1	A1	1.7492	1.7490	1.7491	.0001	.0002	5	A1	1.7491	1.7489	1.7491		.0002
	B1	1.7491	1.7490	1.7491		.0002		B1	1.7491	1.7489	1.7491		.0002
	OR	.0001	.0000	.0000				OR	.0000	.0000	.0000		
2	A2	1.7491	1.7489	1.7491		.0002	6	A2	1.7492	1.7490	1.7492		.0002
	B2	1.7491	1.7489	1.7491		.0002		B2	1.7492	1.7490	1.7492		.0002
	OR	.0000	.0000	.0000				OR	.0000	.0000	.0000		
3	A3	1.7491	1.7489	1.7491		.0002	7	A3	1.7492	1.7490	1.7492		.0002
	B3	1.7491	1.7490	1.7491	.0001	.0001		B3	1.7492	1.7490	1.7492		.0002
	OR	.0000	.0001	.0000				OR	.0000	.0000	.0000		
4	A1	1.7491	1.7490	1.7491		.0001	8	A1	1.7495	1.7493	1.7495		.0002
	B1	1.7491	1.7489	1.7491		.0002		B1	1.7495	1.7493	1.7495		.0002
	OR	.0000	.0001	.0000				OR	.0000	.0000	.0000		
	A2							A2					
	B2							B2					
	OR							OR					
	A3							A3					
	B3							B3					
	OR							OR					
	A1							A1					
	B1							B1					
	OR							OR					
	A2							A2					
	B2							B2					
	OR							OR					
	A3							A3					
	B3							B3					
	OR							OR					
	A1							A1					
	B1							B1					
	OR							OR					

G. P. Grembos 8/9/83



**PISTON RING THICKNESS
AND WIDTH
(LAB. SOP.)**

DATE
12 Sep 83

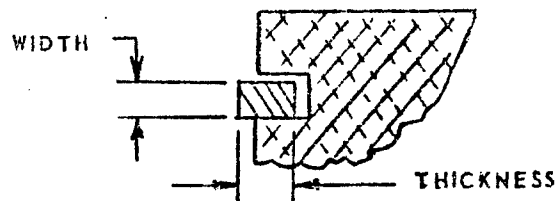
SHEET OF

ENGINE NO.
Cummins VTA-903

WORK ORDER
RZ610133

RECORDED BY
DRSTA-QAA

CHECKED BY
G. Grembos



CYL. NO.		THICKNESS RING NO. OIL						WIDTH RING NO. OIL					
		TOP	2	3	4	5	6	TOP	2	3	4	5	6
1	MAX.	.1130		.1460		.1860		.207		.205		.159	
	MIN.	.1125		.1455		.1855		.204		.204		.157	
2	MAX.	.1145		.1455		.1860		.205		.206		.160	
	MIN.	.1140		.1450		.1850		.202		.203		.157	
3	MAX.	.1150		.1465		.1860		.206		.206		.159	
	MIN.	.1140		.1460		.1855		.203		.204		.156	
4	MAX.	.1150		.1450		.1860		.207		.209		.160	
	MIN.	.1145		.1445		.1855		.204		.204		.155	
5	MAX.	.1150		.1460		.1860		.205		.211		.162	
	MIN.	.1140		.1450		.1860		.203		.208		.157	
6	MAX.	.1165		.1465		.1860		.208		.205		.159	
	MIN.	.1160		.1455		.1855		.205		.203		.156	
7	MAX.	.1150		.1455		.1860		.206		.210		.158	
	MIN.	.1140		.1450		.1855		.203		.215		.155	
8	MAX.	.1135		.1460		.1860		.207		.206		.158	
	MIN.	.1130		.1455		.1855		.205		.202		.156	
	MAX.												
	MIN.												
	MAX.												
	MIN.												
	MAX.												
	MIN.												
	MAX.												
	MIN.												

TAC FORM
22 JUL 60 4534 F

G. Grembos
G-9

09/12/83



CYLINDER LINER BORES

RIGHT BANK

DATE
13 Sep 83

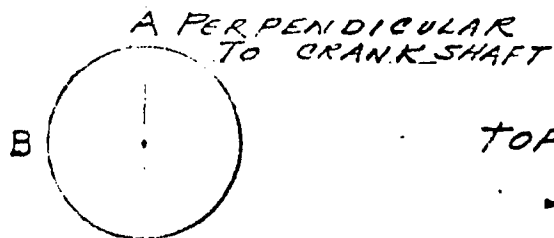
ENGINE NO
Cummins VTA-903

RECORDED BY
DRSTA-QAA

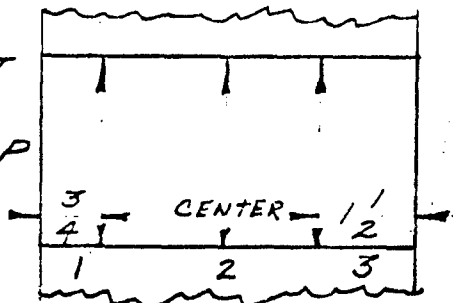
SHEET OF

SERIAL NO.
RZ610133

CHECKED BY
G. Grembos

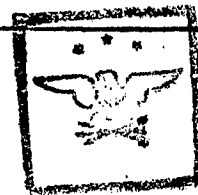


TOP



CYL NO.	LOC.	POSITION				REMARKS
		1	2	3	TAPER	
1	A	5.4995	5.4998	5.4992	.0006	AVERAGE DIA = 5.4999
	B	5.5000	5.5008	5.5004	.0008	
	OR	.0005	.0010	.0012		
2	A	5.4993	5.4998	5.4993	.0005	AVERAGE DIA = 5.4999
	B	5.5005	5.5008	5.5000	.0008	
	OR	.0012	.0010	.0007		
3	A	5.4991	5.5002	5.4996	.0011	AVERAGE DIA = 5.5001
	B	5.5008	5.5012	5.4999	.0013	
	OR	.0017	.0010	.0003		
4	A	5.4999	5.5004	5.4994	.0010	AVERAGE DIA = 5.5001
	B	5.5004	5.5011	5.4999	.0012	
	OR	.0005	.0007	.0005		
	A					
	B					
	OR					
	A					
	B					
	OR					

G. Grembos
09/13/83



CYLINDER LINER BORES

LEFT BANK

DATE
13 Sep 83

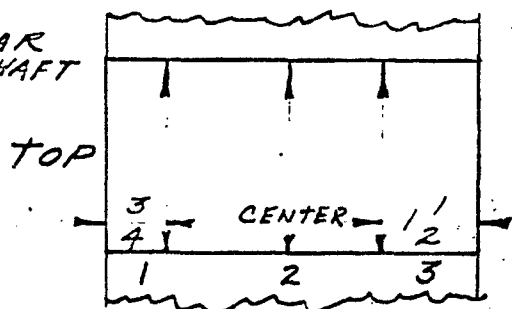
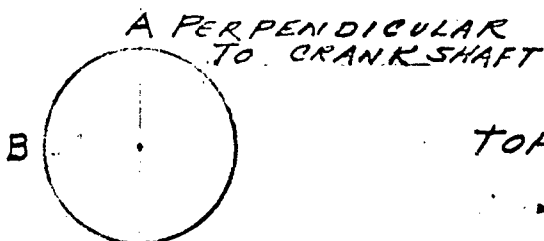
ENGINE NO
Cummins VTA-903

RECORDED BY
DRSTA-QAA

SHEET OF

SERIAL NO.
RZ610133

CHECKED BY
G. Grembos



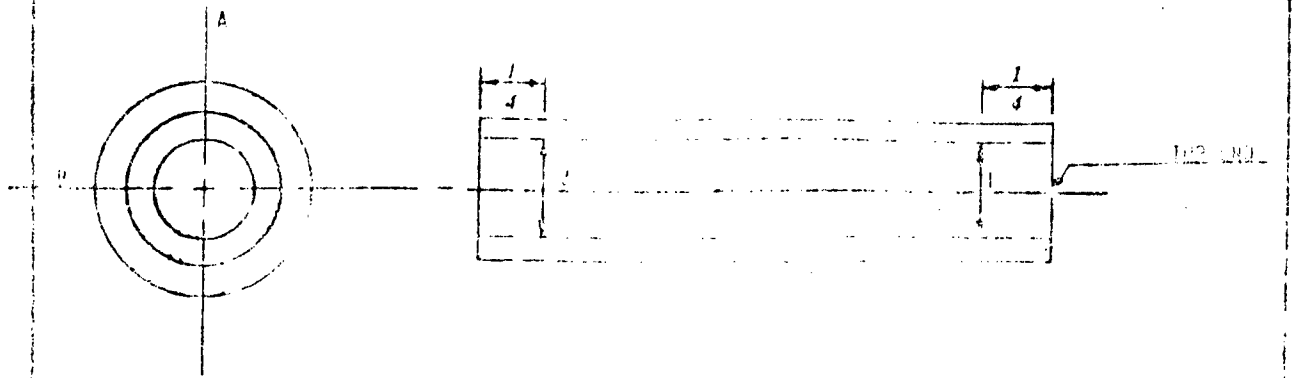
CYL NO.	LOC.	POSITION				REMARKS
		1	2	3	TAPER	
5	A	5.4992	5.5004	5.4994	.0012	AVERAGE DIA = 5.5000
	B	5.4999	5.5012	5.5001	.0013	
	OR	.0007	.0008	.0007		
6	A	5.4996	5.4998	5.4990	.0008	AVERAGE DIA = 5.4998
	B	5.5002	5.5008	5.4996	.0012	
	OR	.0006	.0010	.0006		
7	A	5.4998	5.5005	5.5000	.0007	AVERAGE DIA = 5.5002
	B	5.5002	5.5013	5.4996	.0017	
	OR	.0004	.0008	.0004		
8	A	5.4998	5.5008	5.4998	.0010	AVERAGE DIA = 5.5002
	B	5.5002	5.5009	5.4998	.0011	
	OR	.0004	.0001	.0000		
	A					
	B					
	OR					
	A					
	B					
	OR					

G. Grembos
09/13/83



~~XXXX~~ VALVE GUIDE BORE DIMENSIONS
(LAB. SOP.)

DATE 10 Sep 83	SHEET OF
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY G. GREMBOS



CYL. NO.	LOC.	POSITION			CYL. NO.	LOC.	POSITION		
		1	2	3			1	2	3
1a Int	A	.4533	.4533	.0000	1b Exh	A	.4532	.4520	.0012
	B	.4533	.4535	.0002		B	.4531	.4520	.0011
	OR	.0000	.0002			OR	.0001	.0000	
1c Int	A	.4537	.4537	.0000	1d Exh	A	.4535	.4535	.0000
	B	.4528	.4525	.0003		B	.4528	.4528	.0000
	OR	.0009	.0012			OR	.0007	.0007	
2a Int	A	.4536	.4537	.0001	2b Exh	A	.4535	.4534	.0001
	B	.4538	.4535	.0003		B	.4525	.4525	.0000
	OR	.0002	.0002			OR	.001	.0009	
2c Int	A	.4538	.4530	.0008	2d Exh	A	.4536	.4530	.0004
	B	.4538	.4528	.001		B	.4535	.4530	.0005
	OR	.0000	.0002			OR	.0001	.0000	
	A					A			
	B					B			
	OR					OR			
	A					A			
	B					B			
	OR					OR			
	A					A			
	B					B			
	OR					OR			



XXXXX VALVE GUIDE BORE DIMENSIONS
(L.A.B. SOP.)

DATE
10 Sep 83

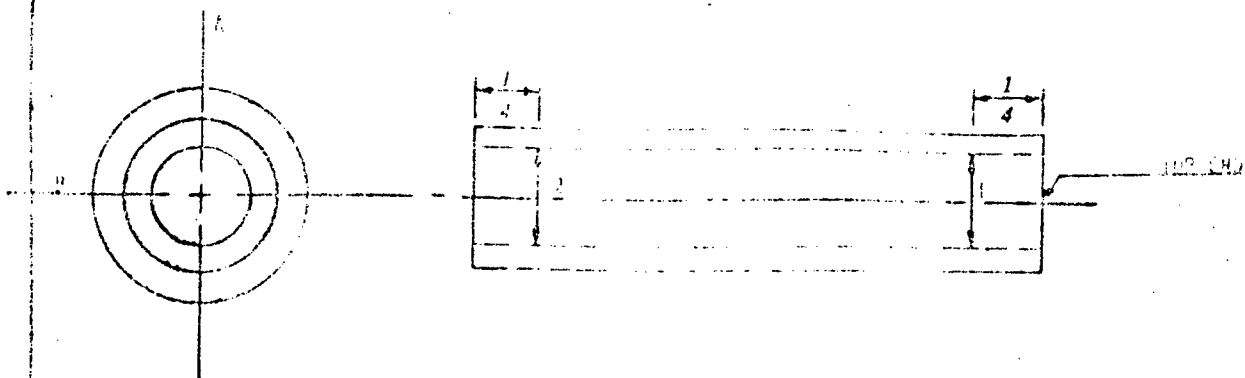
SHEET 1 OF

ENGINE NO.
Cummins VTA-903

WORK ORDER
RZ610133

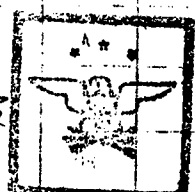
REWORKED BY
DRSTA-QAA

CHECKED BY
G. Grembos



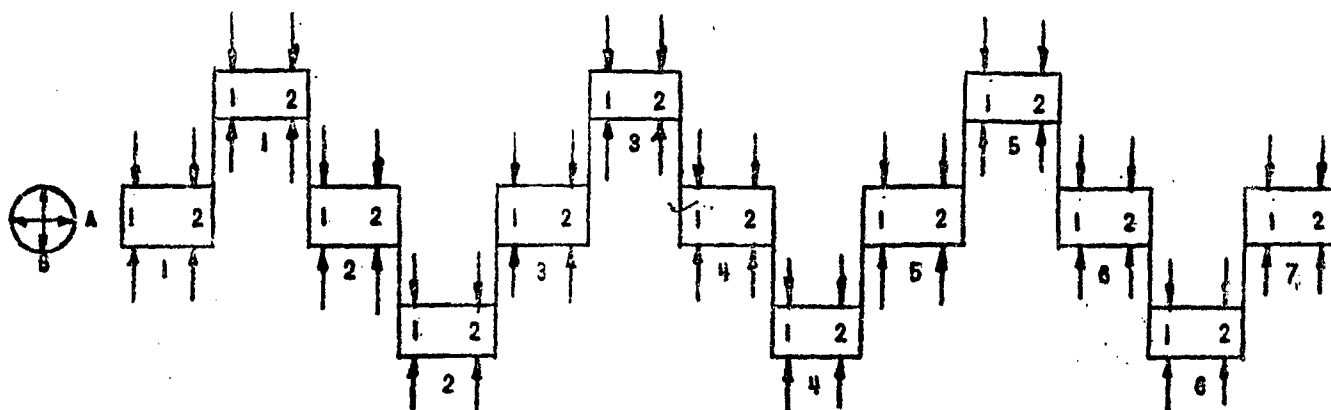
CYL. NO.	LOC.	POSITION		TAPER	CYL. NO.	LOC.	POSITION		TAPER
		TOP	BOTTOM				TOP	BOTTOM	
3a Int	A	.4534	.4525	.0009	3b Exh	A	.4535	.4520	.0015
	B	.4534	.4525	.0009		B	.4536	.4523	.0013
	OR	.0000	.0000			OR	.0001	.0003	
3c Int	A	.4538	.4529	.0009	3d Exh	A	.4538	.4523	.0015
	B	.4541	.4527	.0014		B	.4537	.4525	.0012
	OR	.0003	.0002			OR	.0001	.0002	
4a Int	A	.4533	.4525	.0008	4b Exh	A	.4533	.4528	.0005
	B	.4533	.4525	.0008		B	.4535	.4530	.0005
	OR	.0000	.0000			OR	.0002	.0002	
4c Int	A	.4537	.4525	.0012	4d Exh	A	.4535	.4530	.0005
	B	.4537	.4525	.0012		B	.4535	.4535	.0000
	OR	.0000	.0000			OR	.0000	.0005	
	A					A			
	B					B			
	OR					OR			
	A					A			
	B					B			
	OR					OR			

G.P. Grembos 10/9/83



CRANKSHAFT JOURNAL AND CRANKPIN DIAMETERS
(LAB. SOP.)

DATE	SHEET OF
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY G. Furton



NOTE: Crankpin #1 is in vertical position.

JOURNAL		MAIN JOURNAL DIAMETERS				CRANKPIN		CRANKPIN DIAMETERS			
NO.	LOC.	1	2	TAPER	WEAR	NO.	LOC.	1	2	TAPER	WEAR
1	A	3.7495	3.7497	.0002		4	A	3.1248	3.1248	.0000	
	B	3.7498	3.7496	.0002			B	3.1247	3.1247	.0000	
	O-R	.0003	.0001				O-R	.0001	.0001		
1	A	3.1242	3.1234	.0002		5	A	3.7496	3.7494	.0002	
	B	3.1241	3.1243	.0002			B	3.7493	3.7493	.0000	
	O-R	.0001	.0001				O-R	.0003	.0001		
2	A	3.7498	3.7495	.0003			A				
	B	3.7497	3.7496	.0001			B				
	O-R	.0001	.0001				O-R				
2	A	3.1248	3.125	.0003			A				
	B	3.1247	3.1249	.0002			B				
	O-R	.0001	.0001				O-R				
3	A	3.7498	3.7496	.0002			A				
	B	3.7495	3.7496	.0001			B				
	O-R	.0003	.0000				O-R				
3	A	3.1248	3.1246	.0002			A				
	B	3.1248	3.1245	.0003			B				
	O-R	.0000	.0001				O-R				
4	A	3.7497	3.7497	.0000			A				
	B	3.7495	3.7496	.0001			B				
	O-R	.0002	.0001				O-R				



CONNECTING ROD BEARING SHELL THICKNESS

DATE

6 Sep 83

SHEET

OF

ENGINE NO.

Cummins VTA-903

WORK ORDER

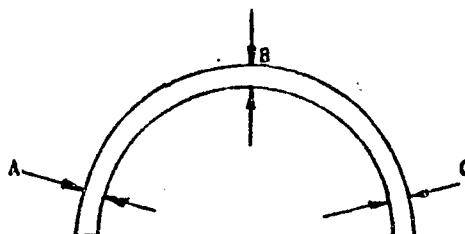
RZ610133

RECORDED BY

DRSTA-QAA

CHECKED BY

D. Melanshek



CONN. ROD NO.	UPPER HALF					CONN. ROD NO.	LOWER HALF				
	LOC.	FRONT	REAR	TAPER	WEAR		LOC.	FRONT	REAR	TAPER	WEAR
1	A	.1540	.1540	.0000		1	A	.1538	.1538	.0000	
	B	.1545	.1544	.0001			B	.1543	.1543	.0000	
	C	.1530	.1535	.0005			C	.1536	.1536	.0000	
2	A	.1535	.1535	.0000		2	A	.1532	.1535	.0003	
	B	.1545	.1543	.0002			B	.1542	.1542	.0000	
	C	.1531	.1535	.0004			C	.1536	.1536	.0000	
3	A	.1537	.1535	.0002		3	A	.1535	.1535	.0000	
	B	.1542	.1540	.0002			B	.1540	.1540	.0000	
	C	.1533	.1533	.0000			C	.1536	.1535	.0001	
4	A	.1532	.1532	.0000		4	A	.1535	.1535	.0000	
	B	.1543	.1541	.0002			B	.1538	.1540	.0002	
	C	.1538	.1538	.0000			C	.1533	.1535	.0002	
5	A	.1535	.1535	.0000		5	A	.1534	.1534	.0000	
	B	.1543	.1544	.0001			B	.1542	.1542	.0000	
	C	.1535	.1535	.0000			C	.1536	.1536	.0000	
	A						A				
	B						B				
	C						C				



D. M.
9.20.83

EXHAUST AND INTAKE VALVE STEM DIMENSIONS
(LAB 50F)

DATE

8 Sep 83

SHEET

OF

ENGINE NO.

Cummins VTA-903

WORK ORDER

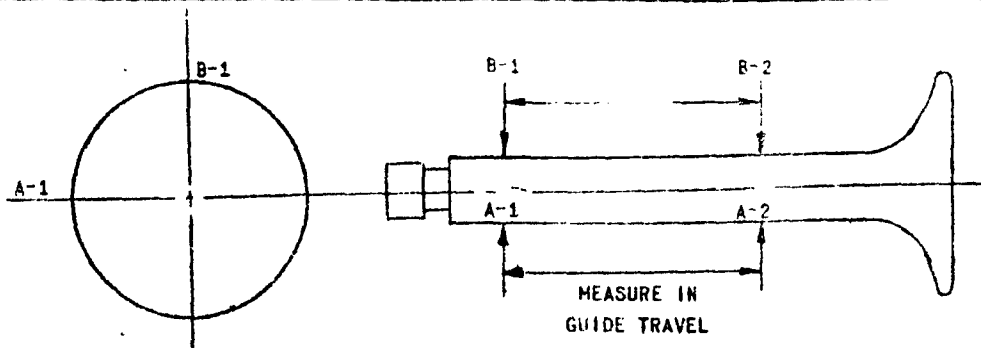
RZ610133

RECORDED BY

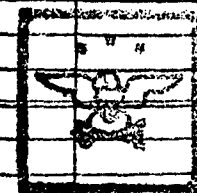
DRSTA-QAA

CHECKED BY

D. Melanshek



CYL. NO.	LOC.	POSITION		TAPER	CYL. NO.	LOC.	POSITION		TAPER
		1	2				1	2	
EXH. # 1	A	.4500	.4500	.0000	EXH. # 1	A	.4503	.4503	.0000
	B	.4500	.4500	.0000		B	.4503	.4503	.0000
	OR	.0000	.0000	.0000		OR	.0000	.0000	.0000
INT. # 1	A	.4505	.4502	.0003	INT. # 1	A	.4505	.4502	.0003
	B	.4503	.4503	.0000		B	.4505	.4502	.0003
	OR	.0002	.0001	.0001		OR	.0000	.0000	.0000
EXH. # 2	A	.4507	.4503	.0004	EXH. # 2	A	.4500	.4502	.0002
	B	.4507	.4504	.0003		B	.4500	.4501	.0001
	OR	.0000	.0001	.0001		OR	.0000	.0001	.0001
INT. # 2	A	.4504	.4498	.0006	INT. # 2	A	.4506	.4501	.0005
	B	.4503	.4498	.0005		B	.4505	.4501	.0004
	OR	.0001	.0000	.0001		OR	.0001	.0000	.0001
EXH. # 3	A	.4502	.4502	.0000	EXH. # 3	A	.4499	.4499	.0000
	B	.4502	.4502	.0000		B	.4499	.4499	.0000
	OR	.0000	.0000	.0000		OR	.0000	.0000	.0000
INT. # 3	A	.4502	.4500	.0002	INT. # 3	A	.4505	.4505	.0000
	B	.4502	.4498	.0004		B	.4505	.4505	.0000
	OR	.0000	.0002	.0002		OR	.0000	.0000	.0000
EXH. # 4	A	.4505	.4505	.0000	EXH. # 4	A	.4502	.4502	.0000
	B	.4505	.4505	.0000		B	.4503	.4501	.0002
	OR	.0000	.0000	.0000		OR	.0001	.0001	.0001
INT. # 4	A	.4505	.4498	.0007	INT. # 4	A	.4504	.4502	.0002
	B	.4505	.4498	.0007		B	.4504	.4502	.0002
	OR	.0000	.0000	.0007		OR	.0000	.0000	.0002
EXH. #	A				EXH. #	A			
	B					B			
	OR					OR			
INT. #	A				INT. #	A			
	B					B			
	OR					OR			
EXH. #	A				EXH. #	A			
	B					B			
	OR					OR			
INT. #	A				INT. #	A			
	B					B			
	OR					OR			



9-20-83

APPENDIX H
NATO REQUIRED DATA SHEETS
FULL LOADS AT 100 HOUR INTERVALS
PART LOADS AT ENDURANCE COMPLETION

ENGINE		Type:	Nº:	Place date:					
FULL CHARGE PERFORMANCES				Reference:					
FUEL:		OIL type:		BRAKE type:					
Volume mass:		kg/dm³	grade:		Full Load at 0 Test Hours				
AMBI- ENT	t0	°C	34.5	30.1	30.2	30.01	29.9	29.7	29.6
	p0	mbar	998.9	998.9	998.9	998.9	998.9	998.9	998.9
ELECTRICITY	n	rpm	2600	2400	2200	2000	1800	1600	1400
	M	mdoN	1387	1439	1420	1386	1334	1258	1151
	p	kw	378	362	327	290	252	211	169
	pme	bar	11.8	12.2	12.1	11.8	11.3	10.7	9.8
FUEL	Es/bstfg/kwh		231	223	217	218	223	228	246
	Qc	mm³/cycle	156.6	165.7	158.6	156.3	153.5	148.8	146.1
	qm	kg/h	82.6	80.6	70.8	63.4	56	48.3	43.5
OIL	TH	°C	119	118.2	116.7	115.7	114.5	113.4	112.5
	PH	bar	3.91	3.58	3.39	3.07	2.73	2.42	2.07
WATER	Te	°C	90.7	90.9	90.98	92.1	91.2	90.89	90.7
	Ts	°C	94.2	94.4	94.3	94.33	94.4	94.55	94.5
INLET	p1	°C	29.39	30.16	30.23	30.01	29.95	29.7	29.59
	p0 - p1	mbar	11.35	9.96	7.77	5.45	3.64	2.46	1.44
	T2	°C	153.33	144.4	129.87	113.88	97.6	82.58	
	p2	bar	1.224	1.173	1.083	.833	.634	.457	.298
	T2'	°C	102.3	100.477	97.4	94.8	92.44	90.7	89.55
	p2 - p2'	mbar	---	---	---	---	---	---	---
EXHAUST	T3	°C	672.9	651.1	637	645.7	662	706.9	738.7
	p3	bar	1.185	1.032	.329	.626	.440	.308	.198
	T4	°C	554.4	537	537	557	595.4	634.8	670
	p4 - p0	mbar	38.17	28.8	17.35	7.47	2.96	.32	1.42
	Smoke	besch	---	---	---	---	---	---	---
BLOW - BY	dm³/mn								

ENGINE		Type:	Nº:	Place date:						
FULL CHARGE PERFORMANCES				Reference:						
INITIAL		FINAL								
FUEL:		OIL type:		BRAKE type:						
Volume mass:		kg/dm ³	grade:	Full Load At 100 Test Hrs.						
AMBI- ENT	t ₀	°C	30.8	31.1	29.7	31.1	30.5	30.8	31.1	
	p ₀	mbar	987.6	987.6	987.6	987.6	987.6	987.6	987.6	
MOTOR VALVE	n	r.p.m	2600	2400	2200	2000	1800	1600	1400	
	M	mdaH	1411	1442.8	1425.2	1398	1352	1267	1162	
	P	kw	384.4	362.6	328.3	292.8	254.8	211.9	170.3	
	p _{me}	bar	11.9	12.2	12.1	11.9	11.5	10.7	9.86	
FUEL	Es/bstc	g/kwh	216	223.2	217.8	216.6	221.4	230.5	247.6	
	Qc	nm ³ /cycle	157	166.2	176	156.1	154.7	150.7	148.7	
	qm	kg/h	82.8	80.9	71.2	63.31	56.5	48.9	42.2	
OIL	PH	°C	117.8	117.2	115.7	115	113.9	112.7	111.2	
	pH	bar	4.72	4.42	4.1	3.64	3.14	2.67	2.2	
WATER	t _e	°C	90.6	89.5	89.76	90.7	90.5	90.2	90.1	
	t _s	°C	94.5	93.7	93.6	94.3	94.27	94.14	94.3	
INLET	t ₁	°C	22.4	23.4	23.9	24.9	24.9	26.2	26.3	
	p ₀ - p ₁	mbar	13.3	11.9	9.5	7.2	5.33	3.9	4.18	
	t ₂	°C	149.3	138.9	123.5	105.4	93.1	78.5	65.3	
	p ₂	bar	1.27	1.213	1.10	.869	.663	.465	.301	
	t ₂ '	°C	103.9	100.8	96.9	93.9	90.5	88.3	87.06	
	p ₂ - p ₂ '	mbar	---	---	---	---	---	---	---	
EXHAUST	t ₃	°C	667.1	637.1	622.4	633.3	661.7	696	729	
	p ₃	bar	1.23	1.083	.868	.659	.469	.313	.199	
	t ₄	°C	496.2	486.7	452	466.2	574	615.5	658.6	
	p ₄ - p ₀	mbar	36.9	25.12	15.3	6.00	1.27	.72	1.997	
	Smoke	besch	---	---	---	---	---	---	---	
	BLOW - BY	dm ³ /mn								

ENGINE		Type:	No.:		Place date:					
FULL CHARGE PERFORMANCES					Reference:					
FUEL:		OIL type:		BRAKE type:						
Volume mass:		kg/dm ³	grade:		Full Load At 200 Test Hours					
AMBI- ENT	t ₀	°C	33.0	33.2	32.5	34	32.3	30.7	29.5	
	p ₀	mbar	1006	1006	1006	1006	1006	1006	1006	
PERFORMANCE	n	r.p.m	2600	2400	2200	2000	1800	1600	1400	
	M	mdaN	1385.8	1441.4	1432	1402	1348	1273	1167.5	
	P	kW	377.2	360.5	330	294	254	213.3	171.1	
	p _{me}	bar	11.76	12.2	12.15	11.9	11.4	10.8	9.91	
FUEL	Es/bstc	g/kWh	230.5	223.8	217.8	214.7	219.6	227.5	237	
	Q _c	nm ³ /cycle	165.1	165.9	161	155.4	152.8	149.5	125.5	
	q _m	kg/h	87.03	80.7	71.8	63	55.7	48.5	40.7	
OIL	T _H	°C	118.2	117.8	116.5	115.2	114.1	112.8	111.2	
	p _H	bar	4.75	4.42	4.08	3.64	3.15	2.67	2.19	
WATER	T _e	°C	90.1	90.8	90.6	90.5	90.4	90.2	90.04	
	T _s	°C	93.7	94.4	94.2	94.1	94.1	94.1	94.2	
INLET	t ₁	°C	20.9	21.9	23.2	23.8	23.5	24.6	24.25	
	p _{0-p1}	mbar	13.9	12.5	10.1	7.64	5.7	4.2	3.18	
	t ₂	°C	144.3	136.3	122.7	107.3	90.9	76.5	63.11	
	p ₂	bar	1.25	1.21	1.061	.865	.660	.466	.302	
	t _{2'}	°C	103.1	101.2	97.6	93.8	90.8	88.32	86.8	
EXHAUST	p _{2-p2'}	mbar	---	---	---	---	---	---	---	
	t ₃	°C	49.9	48.1	46.7	47.5	50.1	53.4	56.3	
	p ₃	bar	1.04	1.05	.846	.643	.457	.321	.186	
	t ₄	°C	542	533	530.4	549.9	582	621.3	654.5	
	p _{4-p0}	mbar	47.2	36.02	20.2	8.34	2.91	.5	.55	
BLOW-BY	Smoke	Besch	---	---	---	---	---	---	---	
	on ³ /min									

ENGINE		Type:	Nº:	Place date:						
FULL CHARGE PERFORMANCES				Reference:						
INITIAL		FINAL								
FUEL:		OIL type:		BRAKE type:						
Volume mass:		kg/dm ³	grade:	Full Load At 300 Hours						
AMBI- ENT	t ₀	°C	29.9	29.4	28.5	24.6	23.5	23.5	23.5	
	p ₀	mbar	996.1	996.1	996.1	996.1	996.1	996.1	996.1	
PERFORMANCE	n	rpm	2600	2400	2203	2000	1801	1601	1400	
	M	mdaN	1383.1	1430.6	1410.2	1373.6	1327.5	1244.8	1139.0	
	P	kW	376.6	359.6	324.8	287.6	250.2	208.6	167.0	
	p _{me}	bar	11.7	12.1	12.0	11.6	11.3	10.6	9.7	
FUEL	K _s /bsfc	g/kWh	233.0	225.7	219.0	220.2	226.9	234.8	250.6	
	Q _c	nm ³ /cycle	199.6	200.0	191.2	187.6	186.6	181.1	177.1	
	q _m	kg/h	87.7	81.1	71.2	63.4	56.8	49.0	41.9	
OIL	T _H	°C	125.1	124.0	121.8	120.0	118.7	117.6	116.0	
	p _H	bar	4.8	4.5	4.3	3.9	3.4	3.0	2.5	
WATER	T _e	°C	89.3	88.8	89.0	89.1	89.1	88.9	88.7	
	T _s	°C	93.1	92.7	92.6	92.5	92.6	92.7	92.6	
INLET	T ₁	°C	27.1	26.6	25.8	22.0	21.1	21.1	21.2	
	p ₀ - p ₁	mbar	15.1	13.6	11.1	8.5	5.9	4.7	3.6	
	T ₂	°C	152.3	142.5	126.2	106.2	89.8	74.1	60.8	
	p ₂	bar	1.22	1.19	1.05	.873	.676	.474	.310	
	T ₂ '	°C	103.7	101.1	97.0	92.5	89.2	86.9	85.3	
	p ₂ - p ₂ '	mbar	---	---	---	---	---	---	---	
EXHAUST	T ₃	°C	671.3	647.3	631.4	633.6	661.3	693.8	725.2	
	p ₃	bar	1.18	1.07	.859	.649	.464	.311	.199	
	T ₄	°C	554.2	539.4	534.9	547.4	580.7	619.0	654.5	
	p ₄ - p ₀	mbar	45.6	36.7	21.8	9.76	4.16	1.64	.299	
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW-BY	dm ³ /min	---	---	---	---	---	---	---		

ENGINE		Type:	Nº:	Place date:						
FULL CHARGE PERFORMANCES				Reference:						
INITIAL		FINAL								
FUEL:		OIL type:		BRAKE type:						
Volume mass:		kg/dm³	grade:	Full Load At 400 Test Hours						
AMBI- ENT	t0	°C	26.0	26.4	26.9	27.3	27.6	27.7	28.3	
	p0	mbar	1002.8	1002.8	1002.8	1002.8	1002.8	1002.8	1002.8	
ELECTRICITY	n	r.p.m	1405	1600	1799	1996	2202	2303		
	M	mdaN	1156.7	1248.9	1342.4	1375.0	1411.6	1417		
	P	kW	169.6	209.2	253.0	287.9	325.2	341.2		
	pme	bar	9.8	10.6	11.4	11.7	12.0	12.0		
FUEL	Es/bsh	g/kwh	240.3	237.8	226.3	221.4	222.0	224.5		
	Qc	dm³/cycle	171.4	184.2	188.1	188.8	194.0	197.1		
	qm	kg/h	40.7	49.8	57.2	63.7	72.2	76.7		
OIL	TH	°C	114.4	118.1	119.9	121.2	122.9	123.9		
	PH	bar	2.6	3.0	3.4	3.9	4.3	4.4		
WATER	Te	°C	88.8	90.6	90.8	90.6	90.7	90.6		
	Ts	°C	92.7	94.2	94.2	94.1	94.1	94.1		
INLET	T1	°C	24.9	25.1	25.2	25.3	25.3	25.7		
	p0 - p1	mbar	3.35	4.31	5.82	7.91	10.51	11.82		
	T2	°C	65.31	78.8	94.7	110.3	125.9	135.0		
	p2	bar	.317	.474	.672	.865	1.06	1.14		
	T2'	°C	85.21	88.71	91.23	94.24	98.21	100.21		
	p2 - p2'	mbar	---	---	---	---	---	---		
EXHAUST	T3	°C	729.4	701.4	665.8	639.9	632.2	637.0		
	p3	bar	.196	.305	.445	.446	.857	.962		
	T4	°C	656.8	626.0	587.7	553.1	534.3	534.0		
	p4 - p0	mbar	.075	1.96	4.90	10.36	22.43	29.27		
	Smoke	Besch	---	---	---	---	---	---		
BLOW - BY	dm³/mn	---	---	---	---	---	---			

ENGINE

PERFORMANCES

Part Load At 1400 RPM

				85%	70%	60%	50%	40%	25%	
AMBI- ENT	t0	°C		25.32	25.58	25.72	25.93	26.04	26.52	
	p0	mbar		1001.2	1001.2	1001.2	1001.2	1001.2	1001.2	
INDICATED PRESSURE	n	r/min		1400	1400	1400	1400	1400	1400	
	M	kg/h		984.5	809.5	694.3	579.0	473.2	297.0	
	P	kw		144.3	118.6	101.8	84.9	69.4	43.5	
	pme	bar		8.4	6.9	5.9	4.9	4.0	2.5	
FUEL	qs/bst	g/kwh		235.4	227.5	236.0	236.0	244.5	276.4	
	qc	mm ³ /cycle		77.1	61.4	55.0	45.0	38.7	27.5	
	qm	kg/h		33.9	27.0	24.1	20.0	17.0	12.1	
OIL	PH	°C		111.3	106.3	107.2	106.1	104.6	103.2	
	pH	bar		2.6	2.8	2.7	2.8	2.8	2.8	
WATER- JETS	te	°C		87.7	86.6	90.6	90.5	91.7	92.8	
	ts	°C		90.7	88.9	92.6	92.2	93.0	93.9	
INLET	t1	°C		23.9	24.3	24.6	24.8	25.1	25.6	
	p0 - p1	mbar		3.2	3.0	3.0	2.9	2.9	2.8	
	t2	°C		54.4	47.8	45.4	42.8	40.6	37.7	
	p2	bar		.46	.33	.27	.22	.17	.11	
	t2'	°C		83.5	82.1	85.4	85.6	85.9	87.3	
	p2 - p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		629.0	539.3	499.7	447.9	401.5	328.7	
	p3	bar		.154	.132	.120	.107	.094	.077	
	t4	°C		576.9	501.8	466.8	419.4	374.5	305.1	
	p4 - p0	mbar		3.46	2.21	1.74	1.02	.049	1.19	
	Smoke	besch	---	---	---	---	---	---	---	
BLOW-BY	cm ³ /min		---	---	---	---	---	---	---	

ENGINE

PERFORMANCES

Part Load At 1600 RPM										
			85%	70%	60%	50%	40%	25%		
AMBI- ENT	t0	°C		25.7	25.0	26.4	26.4	26.7	26.7	
	p0	mbar		998.2	998.2	998.2	998.2	998.2	998.2	
MECHANICAL	n	rpm		1600	1600	1600	1600	1600	1600	
	M	mdaH		1063.0	871.9	744.4	625.1	508.5	309.2	
	P	kW		178.1	146.1	124.8	104.7	85.2	51.8	
	pme	bar		9.0	7.4	6.3	5.3	4.3	2.6	
FUEL	Gs/bst/g/kwh			233.6	231.8	234.2	241.5	247.0	276.8	
	Gc	mm ³ /cycle		153.8	125.4	108.0	93.6	77.7	52.9	
	qm	kg/h		41.6	33.9	29.2	25.3	21.0	14.3	
OIL	TH	°C		114.5	112.1	110.7	109.5	107.8	105.6	
	PH	bar		3.1	3.1	3.2	3.3	3.3	3.4	
WATER	Te	°C		91.4	91.4	92.1	92.7	93.0	93.9	
	Ts	°C		94.3	93.7	93.9	94.2	94.3	94.4	
INLET	T1	°C		24.1	24.5	25.0	25.2	25.4	25.7	
	p0-p1	mbar		4.0	3.7	3.5	3.5	3.3	3.2	
	T2	°C		66.6	58.1	54.1	50.4	46.8	41.8	
	p2	bar		.73	.54	.42	.37	.30	.18	
	T2'	°C		87.9	87.3	87.6	87.9	88.1	88.1	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	T3	°C		631.8	564.9	522.6	478.0	431.2	347.8	
	p3	bar		.250	.211	.190	.170	.150	.121	
	T4	°C		568.8	516.6	480.8	442.8	400.8	323.1	
	p4-p0	mbar		.074	.025	.448	1.19	1.54	2.61	
	Smoke	bsch		---	---	---	---	---	---	
BLOW-BY	dm ³ /mn			---	---	---	---	---	---	

ENGINE										
PERFORMANCES										
Part Load At 1800 RPM										
				- 85%	70%	60%	50%	40%	25%	
AMBI- ENT	t _a	°C		27.8	28.0	28.3	28.7	28.6	28.8	
	p _a	mbar		998.2	998.2	998.2	998.2	998.2	998.2	
MECHANICAL	n	rpm		1800	1800	1800	1800	1800	1800	
	M	mdaH		1141.7	932.9	790.5	672.6	534.3	340.4	
	P	kW		215.2	175.8	149.0	126.8	100.7	64.1	
	p _{me}	bar		9.7	7.9	6.7	5.7	4.5	2.9	
FUEL	Ks/bstc	g/kwh		225.7	226.9	237.8	237.2	245.8	281.0	
	Q _c	mm ³ /cycle		159.4	131.1	116.3	98.6	81.2	59.2	
	q _m	kg/h		48.5	39.9	35.4	30.0	24.7	18.0	
OIL	t _M	°C		116.8	114.7	113.1	111.4	109.6	107.5	
	p _M	bar		3.5	3.5	3.6	3.7	3.7	3.8	
WATER	t _e	°C		90.6	91.6	92.2	92.6	92.7	93.4	
	t _s	°C		93.4	94.1	94.1	94.3	93.9	94.3	
INLET	t ₁	°C		26.0	26.2	26.8	27.3	27.3	27.8	
	p ₀ - p ₁	mbar		5.3	4.7	4.6	4.3	4.0	3.9	
	t ₂	°C		83.1	72.2	67.1	61.5	55.6	49.2	
	p ₂	bar		1.1	.81	.69	.56	.43	.28	
	t ₂ '	°C		89.6	89.6	89.4	89.2	88.8	89.0	
	p ₂ - p ₂ '	mbar		---	---	---	---	---	---	
EXHAUST	t ₃	°C		620.8	569.4	536.0	493.2	442.9	370.3	
	p ₃	bar		.382	.318	.283	.250	.214	.171	
	t ₄	°C		549.7	510.4	484.2	449.4	407.6	341.9	
	p ₄ - p ₀	mbar		3.5	2.2	1.7	1.0	.49	1.19	
	Smoke	bsch		---	---	---	---	---	---	
BLOW - BY	cm ³ /min			---	---	---	---	---	---	

ENGINE

PERFORMANCES

Part Load At 2000 RPM										
			- 85%	- 70%	- 60%	- 50%	- 40%	- 25%		
AMBI- ENT	t0	°C	29.5	29.3	29.1	29.1	29.2	29.3		
	p0	mbar	998.2	998.2	998.2	998.2	998.2	998.2		
MECHANICAL	n	rpm	2000	2000	2000	2000	2000	2000		
	M	mdaH	1174.3	953.3	827.2	679.4	549.2	343.1		
	P	kW	245.9	199.6	173.2	142.3	115.0	71.8		
	pme	bar	10.0	8.1	7.0	5.8	4.7	2.9		
FUEL	Es/bstc	g/kwh	220.8	226.3	232.9	243.9	250.6	285.2		
	Qc	mm ³ /cycle	160.7	133.7	119.5	102.6	85.2	60.7		
	qm	kg/h	54.3	45.2	40.4	34.7	28.8	20.5		
OIL	TH	°C	119.1	116.3	117.4	113.0	111.6	109.0		
	PH	bar	3.8	4.0	4.0	4.1	4.1	4.3		
WATER	Te	°C	92.0	92.0	92.2	92.5	92.8	93.2		
	Ts	°C	94.9	94.3	94.1	94.2	94.0	94.1		
INLET	t1	°C	27.7	27.5	27.4	27.5	27.9	28.1		
	p0-p1	mbar	6.9	6.1	5.8	5.4	5.0	4.5		
	t2	°C	98.3	85.4	79.2	71.7	64.7	54.9		
	p2	bar	1.4	1.1	.95	.78	.60	.39		
	t2'	°C	93.3	91.7	91.2	90.6	90.0	89.4		
	p2-p2'	mbar	---	---	---	---	---	---		
EXHAUST	t3	°C	600.7	559.1	531.3	496.0	452.5	379.8		
	p3	bar	.532	.440	.397	.345	.291	.221		
	t4	°C	523.9	492.1	471.9	444.9	409.7	346.2		
	p4-p0	mbar	6.6	5.0	4.3	3.6	3.1	1.1		
	Smoke	bsch	---	---	---	---	---	---		
BLOW-BY	cm ³ /mn		---	---	---	---	---	---		

ENGINE

PERFORMANCES

Part Load At 2200 RPM										
			- 85%	70%	60%	50%	40%	25%		
AMBI- ENT	t0	°C		27.5	27.7	27.9	28.0	28.8	28.2	
	p0	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
ELECTRO-MECHANICAL	n	rpm		2200	2200	2200	2200	2200	2200	
	M	mda/h		1200	983.1	847.5	705.1	565.4	347.1	
	P	kw		276.4	226.5	195.2	162.4	130.3	79.9	
	pme	bar		10.2	8.3	7.2	6.0	4.8	2.9	
FUEL	Ks/bst/g/kwh			223.8	226.9	232.3	242.7	253.6	295.6	
	Gc	mm ³ /cycle		166.2	138.2	122.1	106.2	89.0	63.5	
	qm	kg/h		61.8	51.4	45.4	39.5	33.1	23.6	
OIL	PH	°C		119.1	116.8	115.5	114.4	112.7	110.4	
	pH	bar		4.4	4.4	4.5	4.5	4.6	4.7	
WATER	te	°C		90.5	91.0	91.6	92.5	92.6	92.9	
	ts	°C		93.4	93.2	93.6	94.2	94.0	93.8	
INLET	t1	°C		25.8	26.2	26.4	26.7	27.0	27.3	
	p0-p1	mbar		8.1	7.5	6.9	5.6	5.5	5.1	
	t2	°C		97.6	89.4	81.8	73.4	60.9	54.3	
	p2	bar		1.4	1.2	1.0	.81	.54	.38	
	t2'	°C		93.5	92.9	92.7	91.8	90.7	90.3	
	p2'-p2	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		552.2	526.6	497.7	460.3	393.6	340.6	
	p3	bar		.594	.516	.453	.379	.287	.237	
	t4	°C		477.2	457.7	436.1	407.6	351.1	304.2	
	p4-p0	mbar		9.3	6.7	5.3	4.4	2.7	1.3	
	Smoke	bosch		---	---	---	---	---	---	
BLOW-BY	dm ³ /mn			---	---	---	---	---	---	

ENGINE

PERFORMANCES

Part Load At 2300 RPM										
			85%	70%	60%	50%	40%	25%		
AMBI- ENT	T0	°C	29.5	29.8	30.0	30.3	30.4	30.4		
	P0	mBar	995.5	995.5	995.5	995.5	995.5	995.5		
MECHANICAL	n	r/min	2300	2300	2300	2300	2300	2300		
	M	kg/H	1209.6	993.9	848.4	709.2	573.6	355.3		
	P	kW	291.3	239.4	204.4	170.8	138.1	85.5		
	PME	bar	10.3	8.4	7.2	6.0	4.9	3.0		
FUEL	Es/baf	g/kwh	222.6	245.7	234.8	245.7	258.5	295.6		
	Qc	mm ³ /cycle	167.0	140.7	123.2	107.8	91.8	65.1		
	qm	kg/h	64.9	54.7	47.9	41.9	35.7	25.3		
OIL	T0	°C	121.8	119.0	116.9	115.4	113.8	111.6		
	P0	bar	4.4	4.5	4.5	4.6	4.6	4.8		
WATER	T0	°C	91.8	91.8	92.0	92.3	92.5	92.9		
	Ts	°C	94.7	94.1	94.1	94.1	94.0	93.8		
INLET	T1	°C	27.4	27.8	28.1	28.6	28.9	29.2		
	P0-P1	mbar	10.4	9.2	8.4	7.7	7.0	6.1		
	T2	°C	120.2	106.3	97.1	89.1	81.0	67.2		
	P2	bar	1.9	1.6	1.3	1.1	.93	.60		
	T2'	°C	98.6	95.8	94.4	93.6	92.9	91.8		
	P2-P2'	mbar	---	---	---	---	---	---		
EXHAUST	T3	°C	596.6	556.7	527.2	500.9	468.9	399.4		
	P3	bar	.794	.667	.578	.504	.435	.326		
	T4	°C	504.5	474.8	453.7	454.4	410.3	354.2		
	P4-P0	mbar	20.0	11.8	8.4	5.5	5.3	3.2		
	Smoke	bsch	---	---	---	---	---	---		
BLOW-BY	dm ³ /mn		---	---	---	---	---	---		

ENGINE										
PERFORMANCES										
Part Load At 2400 RPM										
				85%	70%	60%	50%	40%	25%	
AMBI- ENT	t _a	°C		31.5	31.6	31.7	31.8	31.9	31.8	
	p _a	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
PERFORMANCE	n	r.p.m		2400	2400	2400	2400	2400	2400	
	M	mdaH		1213.6	980.4	854.3	709.2	558.7	345.8	
	P	kw		305.0	246.4	214.5	178.2	140.4	86.9	
	p _{me}	bar		10.3	8.3	7.3	6.0	4.7	2.9	
FUEL	Ks/bst	g/kwh		226.3	232.3	237.2	247.5	263.4	303.5	
	Q _c	mm ³ /cycle		170.1	141.3	125.7	108.7	91.2	65.1	
	q _m	kg/h		69.0	57.3	51.0	44.1	37.0	26.4	
OIL	T _M	°C		122.6	119.4	117.9	116.1	114.7	112.1	
	p _M	bar		4.5	4.6	4.6	4.7	4.8	4.9	
WATER	T _e	°C		91.6	91.6	91.9	92.1	92.5	92.7	
	T _s	°C		94.7	93.8	94.0	93.8	93.8	93.7	
INLET	T ₁	°C		29.2	29.7	29.8	30.0	30.5	30.6	
	p ₀ -p ₁	mbar		11.6	10.0	9.2	8.3	7.6	7.4	
	T ₂	°C		130.7	113.6	104.7	95.5	85.8	71.1	
	p ₂	bar		2.1	1.7	1.4	1.2	.99	.66	
	T ₂ '	°C		100.3	97.2	95.8	94.7	93.9	92.5	
	p ₂ -p ₂ '	mbar		---	---	---	---	---	---	
EXHAUST	T ₃	°C		606.4	558.5	532.6	503.1	467.6	404.4	
	p ₃	bar		.890	.726	.644	.557	.472	.362	
	T ₄	°C		508.4	473.3	454.7	433.6	407.9	356.0	
	p ₄ -p ₀	mbar		27.3	15.2	10.6	7.1	5.5	4.0	
	Smoke	Besch		---	---	---	---	---	---	
BLOW-BY	dm ³ /mn			---	---	---	---	---	---	

ENGINE

PERFORMANCES

Part Load At 2600 RPM										
			85%	70%	60%	50%	40%	25%		
AMBI- ENT	t0	°C	33.1	33.1	33.1	33.0	32.5	32.7		
	p0	mbar	995.5	995.5	995.5	995.5	995.5	995.5		
MECHANICAL	n	rpm	2600	2600	2600	2600	2600	2600		
	M	mdah	1179.7	960.0	827.2	687.5	551.9	343.1		
	P	kw	321.2	261.4	225.2	187.2	150.3	93.4		
	pPe	bar	10.0	8.2	7.0	5.8	4.7	2.9		
FUEL	Gs/bstq/kwh		233.5	234.8	243.3	253.0	272.8	321.1		
	Gc	mm ³ /cycle	170.9	139.5	124.9	107.9	93.3	68.3		
	qm	kg/h	75.1	61.3	54.9	47.4	41.0	30.0		
OIL	TH	°C	124.0	120.9	119.3	117.8	116.5	114.25		
	PH	bar	4.7	4.8	4.8	4.9	4.9	5.1		
WATER- JACKET	Te	°C	91.3	91.5	91.6	92.0	92.4	92.6		
	Ts	°C	94.4	93.9	93.8	93.7	93.8	93.7		
INLET	t1	°C	30.7	30.7	31.1	31.3	30.7	31.5		
	p0 - p1	mbar	13.2	11.7	10.7	9.8	9.0	7.5		
	t2	°C	141.8	124.3	115.8	105.4	95.6	80.6		
	p2	bar	2.2	1.9	1.6	1.4	1.2	.81		
	t2'	°C	102.8	99.7	98.1	96.4	95.4	93.5		
	p2 - p2'	mbar	---	---	---	---	---	---		
EXHAUST	t3	°C	623.2	566.7	537.8	506.6	476.4	418.8		
	p3	bar	1.02	.857	.755	.663	.582	.447		
	t4	°C	516.7	474.8	453.1	430.6	407.9	362.2		
	p4 - p0	mbar	37.3	25.4	17.3	11.4	8.5	5.7		
	Smoke	Bosch	---	---	---	---	---	---		
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