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D. L. ULRICHSON D. E. YAKE OCTOBER 1978

FINAL REPORT

IOWA RE-REFINED OIL FLEET TEST

Prepared for U.S. Department of Energy Contract EY-76-S-02-4074

ISU-ERI-Ames-79033 Project 1266

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DEPARTMENT OF CHEMICAL ENGINEERING
ENGINEERING RESEARCH INSTITUTE
IOWA STATE UNIVERSITY AMES

ISU-ERI-AMES-78310 Project 1266

ABSTRACT

The Iowa Re-refined Oil Fleet Test was designed to obtain comparative performance data on re-refined and virgin 10W-30 motor oils and hydraulic oils in fleet use. The vehicles were provided by the Iowa Department of Transportation (DOT). The re-refined oils were the commercial product from Motor Oils Refining Company and the experimental product was from the Bartlesville Energy Research Center; the virgin oil was DOT standard stock purchased on a low bid basis.

Forty-six vehicles, including 23 passenger cars, 13 pickups, and 10 trucks with hydraulic systems, were operated in normal use with 21 vehicles using virgin oil and 25 vehicles using re-refined oil. Both dipstick and oil drain samples were analyzed by standard ASTM methods. 0il drain intervals of 4,000, 8,000 and 10,000 miles were used.

Analytical results from drain samples were obtained. Twelve representative engines were dismantled and deposit ratings obtained after two years of operation. All pertinent data have been analyzed to compare oil performance and assess the effect of varying drain intervals.

Overall, the two re-refined oils performed at least as well as the virgin oil. In addition, the re-refined oils, particularly the MORCO oil, provided good engine deposit control. Vehicles using MORCO oil generally had higher oil consumption rates. The virgin oil had a marginally low base reserve (total base number) for an 8,000 mile drain interval and showed a larger viscosity increase than the other oils.

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1. INTRODUCTION

In 1975 the Iowa Department of Transportation (DOT) became interested in using re-refined oil in state vehicles. In order to properly assess the performance of re-refined oil, a road test, operating under normal fleet conditions, seemed desirable. The Bartlesville Energy Research Center (BERC), DOE, was also interested in road tests of the oil from their recently developed process [1]. An agreement among the Iowa State University Engineering Research Institute (ISU-ERI), the Iowa DOT, and BERC was reached to test SE-CC Service (10W30) oil from Motor Oils Refining Company (MORCO) and BERC on about 20 vehicles, with a comparable number of vehicles operating on the normal DOT virgin stock under similar conditions.

A lack of significant differences among the three oils would be a useful result and would permit the DOT and other state agencies to allow re-refined oil producers to bid for the state's business. It might also encourage environmentally favorable use of waste oil in Iowa. A closed loop recycle system would be the optimum result.

An evaluation of the potential for recycling oil in Iowa is another objective of this test. The cost of collecting and recycling oil from rural areas is assessed along with the attitude of rural Iowans in general toward using re-refined oil (Appendix E).

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2. RE-REFINED MOTOR OIL PERFORMANCE TESTING

Engine-lubricating oils are specifically formulated with an additive package to provide a given level of lubricating performance under a given type of service (vehicle operating conditions). Bench tests of the motor oil properties, engine sequence tests, and controlled vehicle fleet tests are widely used to evaluate motor oil performance. Growing interest in lubricating oil recycling has prompted research in the area of comparative re-refined and virgin motor oil testing.

Whisman, Goetzinger, and Cotton [2] compared the bench-test properties of re-refined and virgin lubricating oils using standard ASTM tests. According to them, the three re-refined motor oils derived from Bureau of Mines (BERC) re-refining processes and the eight commercially re-refined lubricating oils studied could not be distinguished from the three virgin oils by the bench tests used to define quality.

A major objective of the National Bureau of Standards is an effort to evaluate the quality of recycled oil products ("Measurements and Standards for Recycled Oil"). This is to be accomplished by applying new and existing test methods that are currently being used on virgin oil. This work is intended to produce quality bench scale tests that provide an alternative method to the engine sequence tests for evaluating oil performance [3].

The first documentation in the United States of re-refined lubricating oils successfully passing engine sequence tests was performed by Reynolds, Whisman, and Thompson in 1977 [4]. Re-refined lubricating oils (SAE 10W-30 grade) derived from a BERC re-refining process and a

commercially re-refined SAE 20 grade oil from MORCO designed for SE/CD service were subjected to engine test sequences IIC, IIIC, VC, and L-38. The first three test sequences are the basic specification tests for quality SE motor oils, while the L-38 test (method 3405) is required to meet the standards of military specification Mil-L-46152. These re-refined oils were expected to pass the test sequences, because earlier bench tests [2] indicated no differences between them and quality virgin motor oils.

A recent re-refined oil testing program [5] was completed by the ASTM Re-refined Oil Task Force, EPA, and the U.S. Army. The purpose was to examine possible re-refined oil basestock variations, in addition to estimating the effects that those variations have on the ability of the blended lubricant to qualify under existing U.S. military specifications.

Six different re-refined lubricants were selected, with quality levels ranging from "best" to "low." The base oils differed in chemical and physical properties. The purpose of selecting various quality levels was to determine the corresponding effect on overall engine performance. All six lubricants were formulated with identical additive packages at a specific treating level, and were then subjected to engine sequence and caterpillar 1-H2 tests.

According to J. A. Creedon [5], the test data demonstrates the capability of the six lubricants to meet the military specification requirements with a given additive package. Furthermore, re-refined oils do have satisfactory performance potential to be utilized in formulating lubricants to meet the U.S. military specifications.

Engine sequence tests are designed to evaluate lubricating oil performance under simulated high stress operating conditions that might occur in normal vehicle use. An oil that successfully passes these tests should perform adequately under even the most severe operating conditions. Vehicle fleet tests, on the other hand, can provide "actual" motor oil performance data on vehicles in normal use, providing deposit and wear ratings are performed and compared.

Since fleet tests require much more time to complete and are less controlled than sequence tests, sequence tests are usually preferred.

Certain variables such as constant fuel composition and engine operating conditions are easier to monitor in sequence tests, but are generally difficult to control in fleet tests.

Fleet tests vary in complexity depending on the degree of control that a researcher requires. For example, fleet tests performed by Southwest Research Institute in Texas [6] have operated on a predetermined course with specified fuel supply and detailed used oil analyses. Other tests, such as the one conducted by the city of San Diego, simply operate the vehicles for a predetermined length of time, and then perform deposit and wear ratings on a representative sample [7].

In the past, very few fleet tests have been performed on re-refined motor oil. The San Diego fleet test, which operated solely on re-refined motor oil, was completed in August 1977. Conclusions drawn from the deposit ratings performed on representative vehicles should be used with caution. Overall, the results on the engines using re-refined oils were supportive. The Iowa Re-refined Oil Fleet Test, on the other hand, was designed to provide a more controlled testing program.

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3. TEST PROGRAM

3.1. Summary

This test was designed to obtain comparative performance data on re-refined and virgin 10W-30 motor oils and hydraulic oils in fleet use. The vehicles were provided by the Iowa Department of Transportation.

The re-refined oils were the commercial product from Motor Oils Refining Company and the experimental product from the Bartlesville Energy Research Center.

Forty-six vehicles, including 23 passenger cars, 13 pickups, and 10 trucks with hydraulic systems, were operated under normal conditions with 21 vehicles using virgin oil and 25 vehicles using re-refined oil. Both dipstick and oil change samples were analyzed by standard ASTM methods. Oil drain intervals of 4,000, 8,000 and 10,000 miles were used.

New vehicles were operated up to 3000 miles before the manufacturer's oil was drained, the system flushed and test oil installed. Used vehicles with 13,000 to 27,000 miles of use were similarly treated to determine the effects of switching oil.

Analytical results from oil drain samples were obtained. After two years of operation, twelve representative engines were dismantled and deposit ratings were obtained. All pertinent data were analyzed to compare oil performance and to assess the effect of varying drain interval.

3.2. Description

The new vehicles were run 1000 to 3000 miles on the "original equipment" oil before being switched to the test oil. The used vehicles had accumulated 13,000 to 27,000 miles before being switched to the test oil. The vehicles that completed the test are listed in Tables 1, 2, 3 and 4 by vehicle type. Information regarding engine size, oil drain interval, type of test oil, and initial and final dates and mileages is provided. In addition, the two vehicles that were dropped from the test are identified. A low mileage-accumulating vehicle, A17676 using BERC oil, was dropped to conserve a limited supply of that oil. Vehicle A20386, a Ford 750 truck using virgin oil, needed to be repaired because of excessive oil consumption.

The oils being tested were supplied by Motor Oils Refining Co., Bartlesville Energy Research Center, and the Iowa Department of Transportation from their standard stock. Each oil was formulated to 10W-30 grade and SE/CC service. Tables 5 and 6 present a complete oil characterization of each oil that includes a detailed laboratory analysis and an identified Lubrizol additive package.

All vehicles (except Vehicle 18718, which used Phillips fuel) used Amoco fuel, while the Ford 750 trucks used leaded fuel. Any test vehicle operators who bought fuel with credit cards were instructed to purchase Amoco fuel.

Conversion of the vehicles to the test oil required flushing the system by driving for 30 minutes on the test oil (with a new filter) and then changing oil and filter again (all vehicles used Fram specified air and oil filter types throughout the test). Appropriate labels

Table 1. 1976 Matador wagons.

Vehicle Number	Engine ₃ Size (in ³)	Test Oil	Drain Interval	Initial Mileage Date	Final <u>Mileage</u> Date
A17676 ¹	360	BERC	4,000	2124 8/9/76	177 3 5 0178
A17677	1149 24	MORCO	8,000	$\frac{2700}{8/2/76}$	40833 5/10/78
A17678	1407 124776	VIRGIN	ORCO	2777 8/9/76	45033 6/19/78
A17679	2683 50	MORCO	00,90	$\frac{1516}{8/2/76}$	$\frac{16942}{11/1/77}$
A17680 ²	2100 63	BERC	eren "" 10,0	$\frac{3074}{7/26/76}$	45887 4/26/78
A17681	3677 28	VIRGIN	ROIN	1844 7/28/76	11351 5/8/76
A17682	1687 23	MORCO	URGIN B,C	$\frac{1164}{7/28/76}$	36106 5/5/78
A17683 ²	1853 26	VIRGIN	и.,	$\frac{3144}{7/12/76}$	49503 4/24/78
A17684	75 957017 11 5601	VIRGIN	RGIN "	$\frac{2022}{8/2/76}$	40562 5/15/78
A17685 ²	1509 05	MORCO	H OOK	$\frac{3151}{7/27/76}$	60174 4/24/78
A17686 ²	4006b see at 28	BERC	Nego dgid 160	$\frac{1410}{8/11/76}$	27101 4/26/78
A17687 ²	100mi amy sink 2235 33 /26/76 54		as evolutest RGIN 10,0	1597 7/16/76	48285 4/29/78
A17688 ²	es 1-18 because	VIRGIN	not reporte	2173 7/27/76	54477 4/24/78

This vehicle was dropped from the test to conserve a limited BERC oil supply.

 $^{^{2}}$ This vehicle was involved in the teardown and inspection.

Table 2. 1976 Dodge pickups.

Vehicle Number	Engine Size (in ³)	Test Oil	Drain Interval	Initial <u>Mileage</u> Date	Final <u>Mileage</u> Date
A18707	225	MOR CO	10,000	2231 8/6/76	15177 12/22/77
A18710 ²	4 by veh 3516	MORCO	MC A,0	1002 7/26/76	28617 4/24/78
A18712	2/7/6 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	VIRGIN	8,000	1149 8/18/76	24917 5/11/78
A18713	2777 A2716 pobl e 76/	MORCO	n Widd w Widd	$\frac{1407}{8/24/76}$	8têt cle, A17670
A18714	2/76 110 bg	MORCO	desarya wook	2683 7/27/76	50560 5/10/78
A18716 ²	3074 45 426#16-0023 46	VIRGIN	10,000	2100 7/30/76	63900 4/28/78
A18717	Jeilu belemasi \Z 87\85\	VIRGIN	tuspinedittes	3677 9/15/77	28902 5/15/78
A18718	1164 36 728/981 00v154	VIRGIN	8,000	1685 9/16/76	23143 5/17/78
A18722	11440 20\884B	MORCO	urs and S ervic Lucius a detai	1853 7/28/76	26444 12/29/77
A18729 ²	2022 10 72474601 bei34	VIRGIN	RCIN NIDS	1095 8/10/76	31940 4/24/78
A18731 ²	1191 cololide 127/76 6/6	MORCO	is 18718, sha	1509 11/1/76	45091 4/28/78
A18744 ¹	360	MORCO	10,000	1004 7/26/76	28296 12/27/77
A18745 ¹	86. n <u>102</u> 10 arlar	VIRGIN	10,000	2255 7/26/76	33998 5/8/78

Data from this vehicle was not reported in Figures 1-18 because the engine was different from the other pickups.

 $^{^{2}}$ This vehicle was involved in the teardown and inspection.

Table 3. 1976 F-750 Ford trucks.

Vehicle Number	Engine Size (in ³)	Test 0il	Drain Interval	Initial <u>Mileage</u> Date	Final <u>Mileage</u> Date
A20363	361	VIRGIN	4,000	2487 9/21/76	17799 5/5/78
A20364	16196	VIRGIN	u MT DR	1218 9/21/76	29479 5/9/78
A20365	27866	MORCO	> u ₂	1458 9/21/76	21234 5/16/78
A20366	24160	VIRGIN	" 00.8	1256 11/12/76	10902 4/5/78
A20367	212475	MORCO	n MT DR	1315 9/20/76	16102 12/21/77
A20368	19123 - F	MORCO	008	1568 9/20/76	14240 11/21/77
A20369 ²	1311176 33	MORCO	MCIN .	1364 9/20/76	31676 4/25/78
A20370	25491	MORCO	WIDH	$\frac{1297}{9/21/76}$	17162 12/6/77
A20371 ²	3/10/76, 3/	VIRGIN	0390	1756 9/21/76	27207 4/25/78
A20386 ¹	8/12/76n 9/	VIRGIN	11	$\frac{1045}{9/20/76}$	

¹This vehicle was dropped because of high oil consumption.

 $^{^{2}}$ This vehicle was involved in the teardown and inspection.

Table 4. 1975 Chevrolet Malibus.

Vehicle Number	Engine Size (in ³)	Test Oil	Drain Interval	Initial <u>Mileage</u> Date	Final <u>Mileage</u> Date
A16938	350	MORCO	4,000	19089 8/24/76	43514 11/23/77
A16947	21/76 5/5	VIRGIN	N NIDEL	$\frac{26472}{8/11/76}$	62730 4/4/78
A16955	212 " 5/9 458 " 5/9	VIRGIN	ORCO	16196 8/10/76	36152 3/27/78
A16964	528 92/12, 1/5 92/12,	MORCO	n -	27866 8/11/76	$\frac{48975}{12/21/77}$
A17015	/12/76 4/5 .315 161	MORCO	. u	24160 8/24/76	50389 10/29/77
A17029	20/76 12/	VIRGIN	, GORO	$\frac{21236}{8/11/76}$	46341 4/14/78
A17030	264 316	MORCO	u	19123 8/11/76	42760 3/20/78
A17035	20/76 4/2	VIRGIN	00.20	$\frac{13117}{8/11/76}$	39533 11/28/77
A17042	756 272	VIRGIN	, Michi	25491 8/10/76	50116 3/30/78
A17059	21/76 " 4/2	MORCO	п пкети	$\frac{24557}{8/12/76}$	47890 9/30/77

Table 5. Test oil laboratory analysis.

Laboratory Analyses	MORCO Oil	BERC Oil	VIRGIN Oil
viscosity, SSU @ 100°F	316	375	318
Jiscosity, SSU @ 210°F	61.60	67.85	63.72
Jiscosity Index	136	137	141
ran -	2.15	2.35	1.63
ГВИ	5.43	3.92	3.33
Ash (sulfated) (%)	1.00	1.30	.71
	1.00		
Н	taken at 4,000.	7.4	100 ml 1 kg.
Benzene Insol. Coag.	Ni1	Nil	Nil
Pentane Insol. Coag.	Nil Da	Nil	Nil
Sulfur (%)	.58	.5	.46
Flash, ^O F	405	425	405
Pour, °F	Below -50	Below -50	Below -50
Gravity	29.2	29.2	29.2
Color	4-1/2	2 3 9	3
later	And make Sc Be	Section 18 to 18 t	2000
Suel Dilution	I be allow beautiful	a man Antalia i	end Brown
Spectrographic:ppm	listerled arez mail	2 01	2
Iron Zinc	980	830	820
Lead	0	0	credin 0
Sodium	5	4	16
Calcium	1950	2600	1900
Silicon	4	2	5
Silver		0	0
Copper	0	0	0
Aluminum	0	0	35
Barium	24	25	0
Nickel	0	dusid	0
Chromium	1	1	1
Tin Phosphorus	800	650	650
Boron	0	0	14
Magnesium	650	9	7
Vanadium	0	0	. 0
Molybdenum	0	0	0
Manganese	peples were obtain	acd by meous of	A SUCTO
Cadmium	0	0	0
Titanium	ad was in her o	breugh tho dips	tikok holeo
			long bear
hr @ 210°F Copper Corrosion	Class I	Class I	Class I

Table 6. Test oil additive packages.

Test Oil	Viscosity Index Improver	Multipurpose Additive
BERC 0i1	Lubrizol 3702	Lubrizol 4462
	(Dispersant Type)	
	2-10% (Vol.)	6.8% (Vol.) of Base Stock
MORCO Oil	Lubrizol 3135	Hitec E-703
	(Non-Dispersant Polymethacrylate)	6.7% (Vol.) of Base Stock
VIRGIN Oi1*	Lubrizo1 7013	Lubrizol 4454-E
3	(Poly Ethylene-Propylene)	
	8% (Vol.)	6.7% (Vol.) of Base Stock

^{*}i.e. Mid-Continent Crude.

^{= 70.8%} High V.I. Solvent Extracted 100 Neutral Base.

⁼ 14.8% 150 S.U.S. @ 210° F of Bright Stock.

were then placed on the vehicle to guard against the use of incorrect oil. A log book was placed in each vehicle to record gas consumption, unusual driving conditions, repairs, oil samples, changes, etc. The drivers and mechanics maintained excellent records in these books, and summary information was reported to Iowa State University at the time an oil sample was taken. The log books in the field were periodically inspected by test supervisors.

Oil drain samples were taken at 4,000, 8,000, or 10,000 miles, depending on the specifications for that particular vehicle. The vehicle was driven for 30 minutes to insure a hot oil sample that minimizes fuel dilution. The oil was then drained into a clean pan used only for test oils, thoroughly mixed in the pan, and two one-pint samples were obtained. One of these samples was labeled and stored at the site and the other was labeled and mailed to Motor Oils Refining Co. for analysis. The results of these analyses are reported in Appendix A. Standard ASTM analytical methods (Table 7) were used.

Those vehicles on 8,000 or 10,000 mile oil drain intervals were monitored by means of dipstick samples taken at 2,000 mile intervals for the first oil drain period. This provided a means of preventing possible engine damage resulting from unsatisfactory oil performance at these extended drain intervals.

These intermediate samples were obtained by means of a suction gun fitted with tubing that was inserted through the dipstick hole.

The length of tubing was premeasured, and an end and side hole in the tubing was provided in order to get a representative sample.

Following a satisfactory period of oil performance at 8,000 and

Table 7. Used oil analyses.

Laboratory Analyses:	ASTM Designation	Spectrographic Analyses	
Flash, ^O F	D-92	Lead	Sodium
Viscosity, @ 100°F	D-445	Copper	Calcium
Viscosity, @ 210°F	D-445	Iron	Barium
Viscosity Index	D-2270	Aluminum	Zinc
Benzene Insolubles	D-893	Chromium	Phosphorus
Pentane Insolubles	D-893	Tin	Magnesium
Total Acid Number	D-664	Vanadium	Manganese
Total Base Number	D-664	Molybdenum	Cadmium
Fuel Dilution	D-332	Nickel	Titanium
Antifreeze		Boron	Silver
Water (on selected samples)	D-9 5		Silicon

Those vehicles on 8,000 or 10,000 biles oil drain intervals were contored by means of dipetick samples taken at 2,000 mile intervals:

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10,000 mile drain intervals, the Matador wagons (Table 1), which were originally sampled every 4,000 miles, were switched to 8,000 mile drain intervals. This helped conserve a limited supply of BERC oil and provided increased stress on the oils. Hydraulic oil samples were taken (concurrently with oil drain samples) from the hydraulic reservoir, which was specially fitted with a standpipe/petcock sampler.

This fleet test terminated when the Iowa DOT dismantled 12 engines and Southwest Research Institute personnel performed deposit ratings.

The ratings included a visual rating of sludge and varnish accumulation and observations of rust and corrosion.

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4. FLEET OPERATION DATA

4.1. Introduction

The comparative analysis of re-refined and virgin lubricating oils in this fleet test includes: comprehensive laboratory analyses of oil drain samples; laboratory analyses of hydraulic oil samples; engine wear measurements on 12 vehicles selected for teardown and inspection; and sludge and varnish (deposit) ratings on the 12 vehicles.

It should be emphasized that the vehicles involved in the fleet test are operated under a variety of conditions which may range from high speed/high load to stop and go with high idling time. No attempt has been made to segregate the used oil analyses, wear measurements, or deposit ratings according to specific driving conditions.

Duplicate oil samples that were analyzed by Faber Laboratories of Chicago gave acceptable correlation with MORCO results. All laboratory data reported is from MORCO Laboratories.

The Chevrolet Malibus (Table 4) were operated on the re-refined MORCO oil to assess the effect of switching from a virgin to a re-refined oil. The data, obtained from 4,000 mile oil drain samples, displayed no distinguishing trends related to the switching of oil types, and yielded no additional information to the data obtained from the Matador wagons at a 4,000 mile oil drain interval. All vehicles performed satisfactorily with no engine problems or repairs. Therefore, the Chevrolet Malibus' data will not be analyzed further. Laboratory analyses of the oil drain samples are provided in Appendix A.

The comprehensive analysis of laboratory data from the oil drain samples includes a discussion of oil consumption, wear metal concentrations, total base number, viscosity, pentane insolubles, water concentrations, oil additive metals, and fuel additives.

4.2. Oil Consumption

The number of quarts of oil added per 1,000 miles during each vehicle's oil drain period is plotted as a function of mileage in Figs. 1, 2, and 3. The consumption of MORCO oil is somewhat higher than that of the BERC or VIRGIN oil, as shown in Fig. 1. Similar conclusions can be drawn from data presented in Fig. 2 for the Dodge pickups. The oil consumption data of the Ford trucks shown in Fig. 3 is scattered and inconclusive.

Furthermore, in Fig. 1 the first 24,000 miles represents a period of 4,000 mile oil drain samples, while the remaining samples were taken roughly every 8,000 miles. Oil consumption per 1,000 miles is relatively steady, although an increasing trend can be seen in the 40,000 to 50,000 mile region. This may be a function of the oil drain interval or simply of the mileage.

Generally, the oil consumption rates were higher for the MORCO oil than for the other test oils. In the Matador wagons the mean MORCO, VIRGIN, and BERC oil consumption rates were 0.62, 0.35, and 0.17 qts/1000 miles respectively. A similar trend was noted in the Dodge pickups, where the mean MORCO oil consumption rate was 0.60 qts/1000 miles and the VIRGIN oil was 0.43 qts/1000 miles. However, the mean oil consumption rates in the Ford trucks showed the opposite trend (a mean MORCO oil consumption rate of 1.0 qts/1000 miles and a mean VIRGIN oil consumption

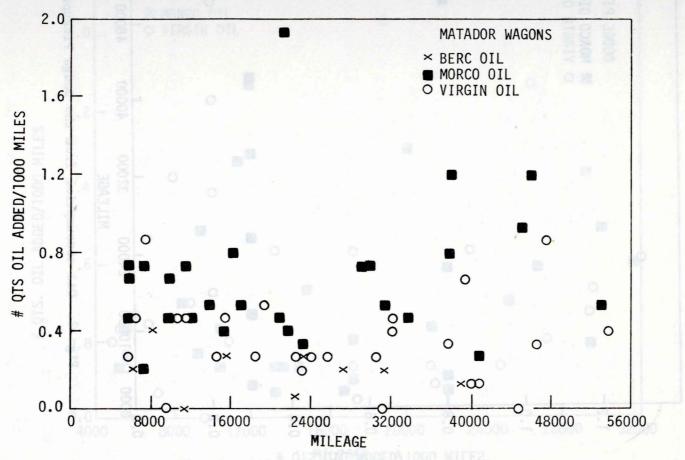


Fig. 1. Oil consumption from the Matador wagons.

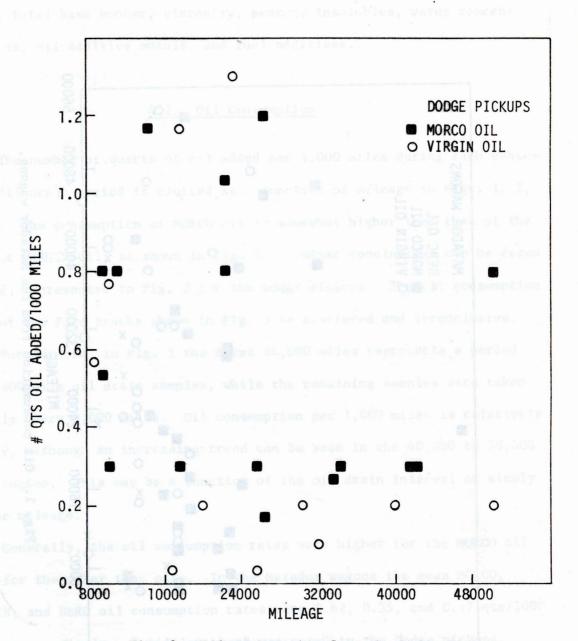


Fig. 2. Oil consumption from the Dodge Pickups.

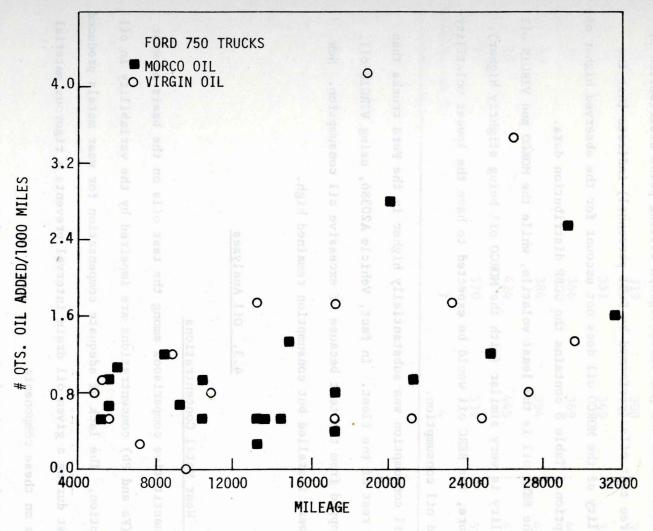


Fig. 3. Oil consumption from the Ford 750 trucks.

rate of 1.2 qts/1000 miles. The oil consumption rates of vehicles involved in the tear down and inspection corresponded favorably with the remainder of the fleet.

Results from the gas chromatograph boiling point distribution of the three test oils (performed by SwRI personnel) indicate that the volatility of the MORCO oil does not account for the observed higher oil consumption. Table 8 contains the GCBP distribution data.

The BERC oil is the least volatile, while the MORCO and VIRGIN oil volatility is very similar (with the MORCO oil being slightly higher).

Therefore, the BERC oil would be expected to have the lowest volatility-related oil consumption.

Oil consumption was substantially higher in the Ford trucks than in the rest of the fleet. In fact, Vehicle A20386, using VIRGIN oil, was dropped from the test because of excessive oil consumption. New rings were installed but consumption remained high.

4.3. Oil Analyses

4.3.1. Wear Metal Concentrations

Quantitative comparisons among the test oils on the basis of wear metal (Fe and Pb) concentrations are impaired by the variability in oil consumption. The lack of adequate compensation for wear metals produced and lost during a given oil drain interval prevents a rigorous material balance on these components.

Several correction factors were proposed to compensate for the oil consumption variations, and varied simplistically with the number of

Table 8. Gas chromatographic boiling point distribution data.

vt % off @ °C	VIRGIN 0i1	MORCO 0i1	BERC Oil
n interval (ODI	319	308	337
5 and Pine C .alt	351 no noe	349	388
10	366	369	403
20	384	394	421
50	424	445	455
90	570	531	525
Residue, wt %	o 7	noo lio mori en	4

than the VIMALIA of Sencentrations. Similar plots using a limited contition the confictors three types of tess vehicles which as additional information.

Retramely high lead concentrations were reported in the Ford trucks that used leaded fund.

According to Fig. 8, lead levels veried from II that used leaded fund.

to 3% at 3 4,000 mile Obje Similarly, from concentrations (Fig. 9) were generally higher than the generally higher than the concentrations were generally higher than the light concentrations were generally higher than the light concentrations, whereas the lead concentration treats also have the concentration of the concentrations were generally higher than the

quarts of oil added during the drain interval. For example, a correction factor, alpha, equal to one plus the ratio of the number of quarts of oil added to the total oil capacity (5 quarts in most cases) is proposed.

Figures 4, 5, 6, and 7 illustrate the effect of alpha on the iron and lead concentrations (PPM) as a function of the oil drain interval (ODI) in the Matador wagons. A comparison of Fig. 4 with Fig. 5 and Fig. 6 with Fig. 7 demonstrates that no significant improvement in the spread of the data is noted. Similar conclusions were drawn from data plotted using other types of functional relationships. Therefore, we will compare the three oils using the iron and lead concentrations directly and overlook effects resulting from oil consumption.

Although the data is scattered, little difference is noted among the test oils for the iron concentrations at a 4,000 mile ODI. At 8,000 miles, however, MORCO oil iron concentrations are significantly lower than the VIRGIN oil concentrations. Similar plots using a limited quantity of data obtained from the other three types of test vehicles yield no additional information.

Extremely high lead concentrations were reported in the Ford trucks that used leaded fuel. According to Fig. 8, lead levels varied from 1% to 3% at a 4,000 mile ODI. Similarly, iron concentrations (Fig. 9) were generally higher than those of other vehicles and ranged from 100 PPM to 1,200 PPM. MORCO oil iron concentrations were generally higher than the VIRGIN oil concentrations, whereas the lead concentration trends displayed an inverse trend (MORCO lead levels lower than the VIRGIN levels).

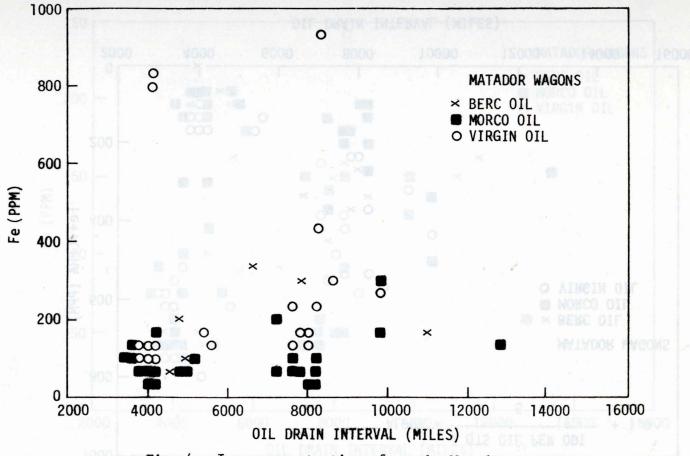


Fig. 4. Iron concentrations from the Matador wagons.

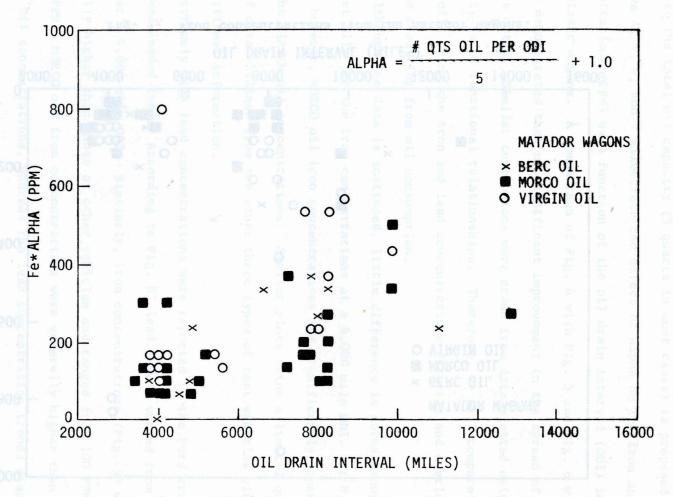


Fig. 5. Modified iron concentrations from the Matador wagons.

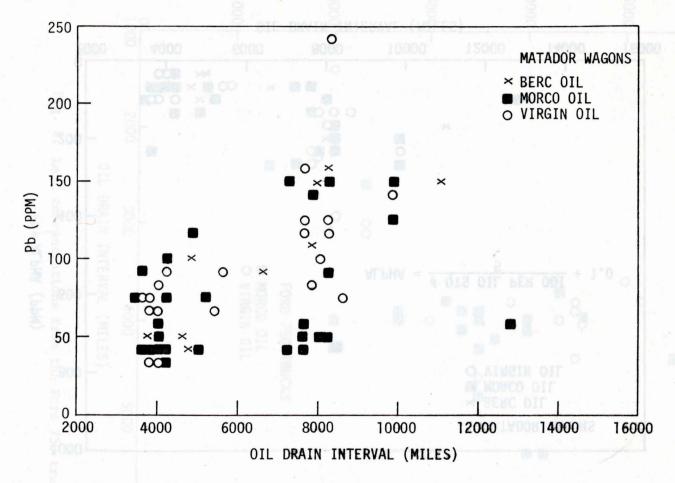


Fig. 6. Lead concentrations from the Matador wagons.

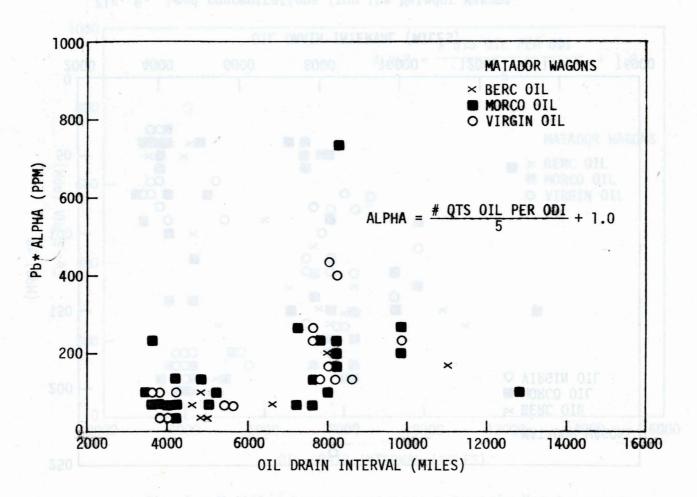


Fig. 7. Modified lead concentrations from the Matador wagons.

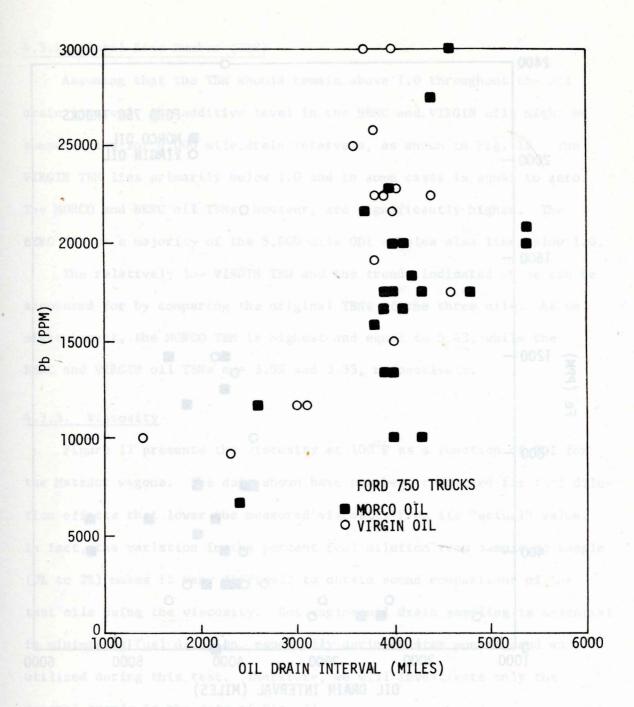


Fig. 8. Lead concentrations from the Ford 750 trucks.

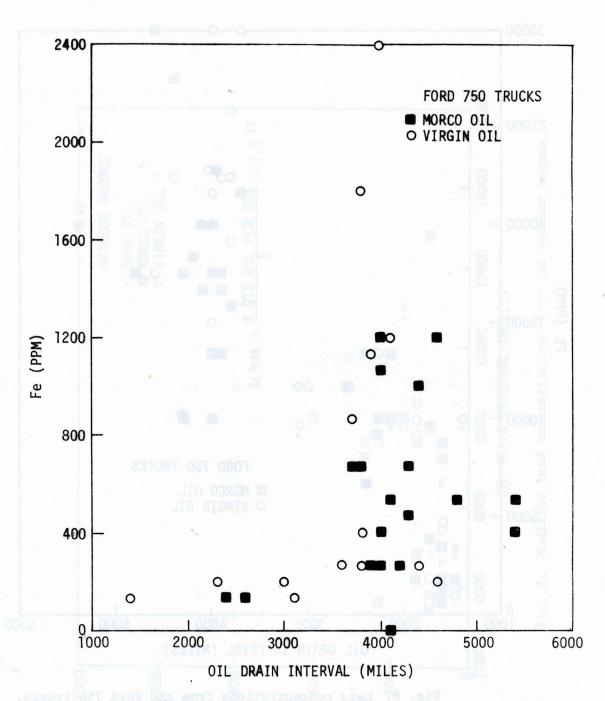


Fig. 9. Iron concentrations from the Ford 750 trucks.

4.3.2. Total Base Number (TBN)

Assuming that the TBN should remain above 1.0 throughout the oil drain interval, the additive level in the BERC and VIRGIN oils might be somewhat low for 8,000 mile drain intervals, as shown in Fig. 10. The VIRGIN TBN lies primarily below 1.0 and in some cases is equal to zero. The MORCO and BERC oil TBNs, however, are significantly higher. The BERC TBN on a majority of the 8,000 mile ODI samples also lies below 1.0.

The relatively low VIRGIN TBN and the trends indicated above can be accounted for by comparing the original TBNs of the three oils. As we might expect, the MORCO TBN is highest and equal to 5.43, while the BERC and VIRGIN oil TBNs are 3.92 and 3.33, respectively.

4.3.3. Viscosity

Figure 11 presents the viscosity at 100°F as a function of ODI for the Matador wagons. The data shown have not been corrected for fuel dilution effects that lower the measured viscosity from its "actual" value. In fact, the variation in the percent fuel dilution from sample to sample (0% to 2%) makes it very difficult to obtain sound comparisons of the test oils using the viscosity. Hot engine oil drain sampling is essential in minimizing fuel dilution, especially during winter months, and was utilized during this test. Therefore, we will investigate only the general trends in the data of Fig. 11.

At the 4,000 mile ODI little difference can be seen among the three test oils. Similarly, the viscosity values at 8,000 miles for the test oils lie in the same region, although nearly half of the VIRGIN oil points lie significantly above it. Generally, the 4,000 mile ODI viscosity values lie between 310 SSU and 425 SSU, whereas the 8,000 mile ODI

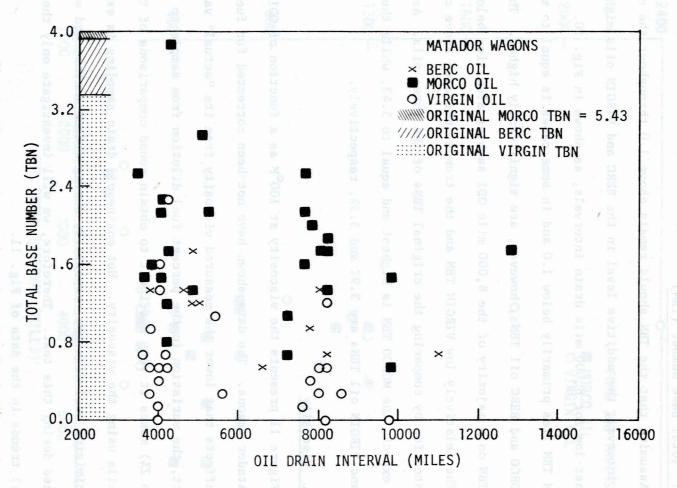


Fig. 10. Total base numbers from the Matador wagons.

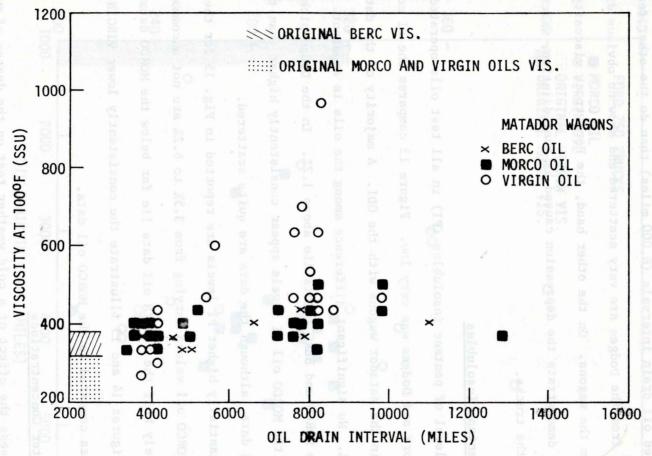


Fig. 11. Viscosity data from the Matador wagons.

viscosity values vary primarily from 340 SSU to 500 SSU. The unusually high VIRGIN viscosity data at an 8,000 mile ODI range from 600 to 1,000 SSU. Apparently, the VIRGIN oil has a slightly higher tendency to thicken at extended oil drain intervals (8,000 miles) than do the other test oils.

Data from the Dodges are very scattered and show no obvious differences from the wagons. On the other hand, the Ford truck viscosity data (Fig. 12) demonstrate the depression caused by fuel dilution, which was high for the trucks.

4.3.4. Pentane Insolubles

The level of pentane insolubles (PI) in all test oils operated in the Matadors and Dodges was very low. Figure 13 compares the PI concentrations in the Matador wagons with the ODI. A majority of the data lies below 0.8%. No significant difference among the oils is apparent. However, some MORCO and BERC points lie above 1.2%. In the Dodge pickups (Fig. 14) the MORCO oil PI levels appear consistently higher than the VIRGIN oil data, although the data are quite scattered.

Substantially higher PI levels are reported in Fig. 15 for the Ford trucks. MORCO oil values varying from 3.5% to 6.2% are not uncommon. Approximately half the VIRGIN oil data lie far below the MORCO data region. Figures 14 and 15 illustrate the consistently lower VIRGIN oil PI levels as compared to the MORCO oil data.

4.3.5. Water Concentrations

To assess the effect of a cold weather test on the degree of water contamination of these oils, various duplicate oil drain samples were analyzed using the ASTM D-95 ($\rm H_2O$ by distillation) technique. Figure 16

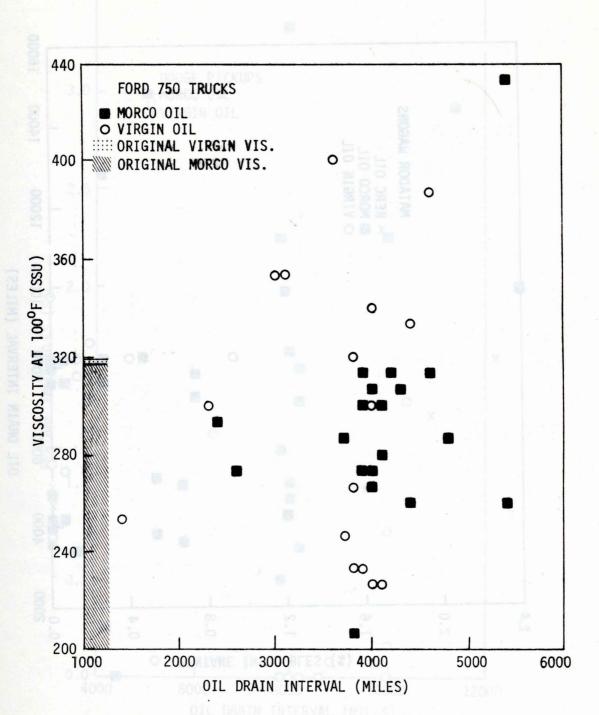


Fig. 12. Viscosity data from the Ford 750 trucks.

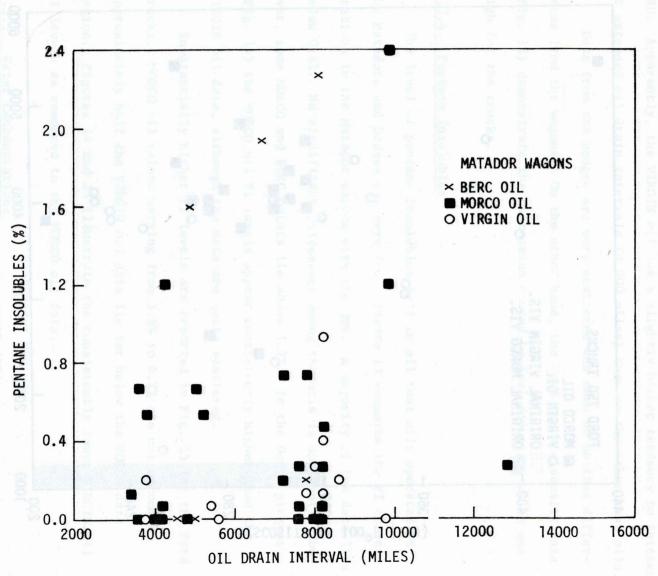


Fig. 13. Pentane insolubles from the Matador wagons.

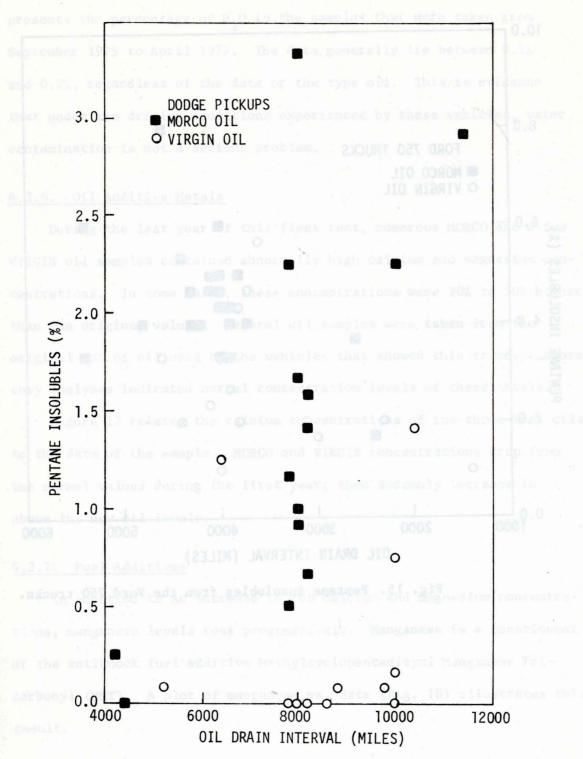


Fig. 14. Pentane insolubles from the Dodge pickups.

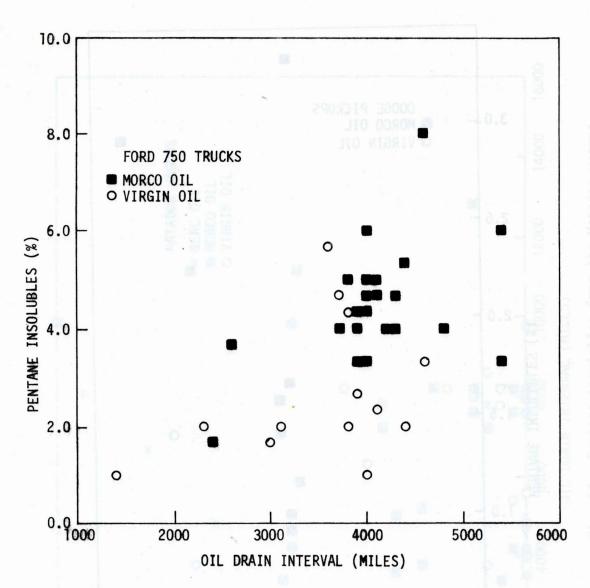


Fig. 15. Pentane insolubles from the Ford 750 trucks.

OIL DRAIN INTERVAL (MILES)

presents the percentage of $\mathrm{H_2^{0}}$ in the samples that were taken from September 1975 to April 1977. The data generally lie between 0.1% and 0.2%, regardless of the date or the type oil. This is evidence that under the driving conditions experienced by these vehicles, water contamination is not a serious problem.

4.3.6. Oil Additive Metals

During the last year of this fleet test, numerous MORCO and a few VIRGIN oil samples contained abnormally high calcium and magnesium concentrations. In some cases, these concentrations were 20% to 50% higher than the original values. Several oil samples were taken from the original lot of oil used by the vehicles that showed this trend. Laboratory analyses indicated normal concentration levels of these metals.

Figure 17 relates the calcium concentrations of the three test oils to the date of the sample. MORCO and VIRGIN concentrations drop from the normal values during the first year, then suddenly increase to above the new oil levels.

4.3.7. Fuel Additives

In addition to an increase in the calcium and magnesium concentrations, manganese levels rose progressively. Manganese is a constituent of the antiknock fuel additive Methylcyclopentadieynl Manganese Tricarbonyl (MMT). A plot of manganese vs. date (Fig. 18) illustrates this result.

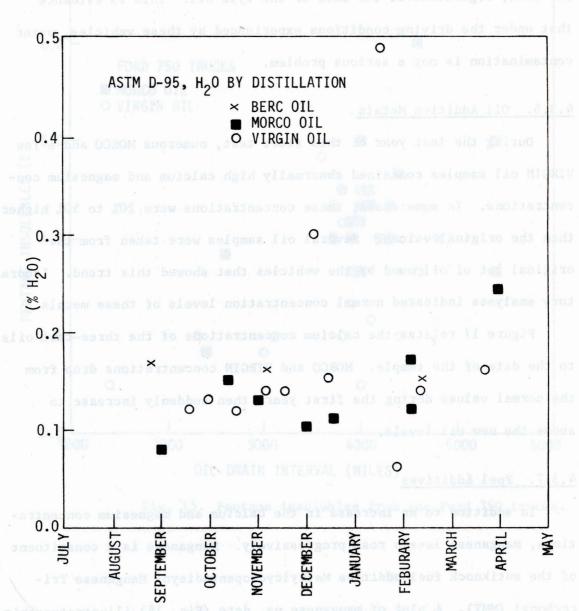


Fig. 16. Water analysis of used oil.

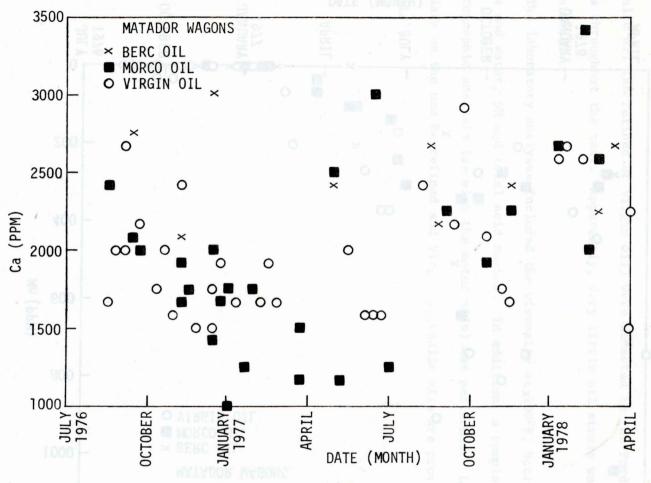


Fig. 17. Calcium concentrations from the Matador wagons.

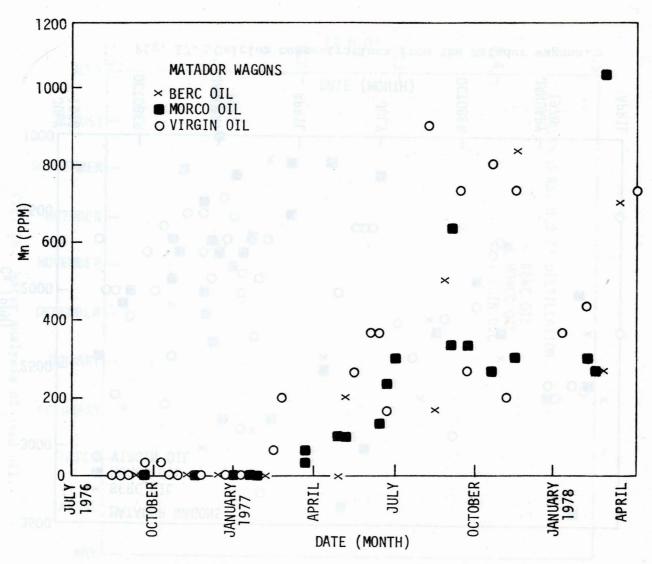


Fig. 18. Manganese concentrations from the Matador wagons.

4.4. Hydraulic Oil Sample Analysis

No significant differences between the new hydraulic oil and used hydraulic oil (Re-refined or Virgin oil) were detected in the Ford 750 trucks throughout the test. Apparently, very little oil stress was encountered.

The laboratory analyses included the viscosity at 100°F, bottoms sludge and water, pH and total acid number. In addition, a complete spectrographic analysis (as with the motor oils) was performed. Laboratory data on the new Re-refined and Virgin hydraulic oils are provided in Table 9.

Table 9. Hydraulic oil laboratory analyses.

Laboratory Analyses	Re-refined Oil	Virgin Oil	
Viscosity, SSU @ 100°F	159	156	
Bottom Sludge and Water	Ni1	Ni1	
very little of a stress was	ut the test. Meparemely	6.1	
Total Acid Number	0.36	1.29	
Spectrographic & PPM	tory, analyses ancluded the		
Iron	r, pH and total acid numi	day be sabo	
Sinc bearoling asw (sale to)	210	760	
ben Lead end allocations are	THE BOOK BOOKED 2 ST WAR IN	d1 no s1s13vii	
Sodium	77	2	
Calcium	21	21	
Silicon	2	3	
Silver	0	0	
Copper	10	8	
Aluminum	0	0	
Barium	1	5	
Nickel	0	0	
Chromium	0	1	
Tin Sala	1	1	
Phosphorus	100	320	
Boron	0	0	
Magnesium	5	0	
Vanadium	0	0 1030	
Molybdenum	0	0	
Manganese	0	0	
Cadmium	0	0	
Titanium	0	0	

5. DEPOSIT INSPECTION AND WEAR MEASUREMENTS

Twelve engines were dismantled by the Iowa DOT and deposit ratings were performed by Southwest Research Institute (SwRI) representatives.

Engines from six Matador wagons, four Dodge pickups, and two Ford trucks were chosen with the assistance of Southwest Research Institute (Table 10). The criteria used to choose the various engines included a reasonably high mileage, comparable accumulated mileage within each vehicle type when possible, an oil consumption that was representative of other vehicles of that type, and low initial iron concentrations in the oil for the purpose of avoiding engines with high initial wear. In addition, engines with operating problems or major repairs were excluded. Appendix B contains the inspection report prepared by Southwest Research Institute.

Engine wear measurements were made on the 12 inspected vehicles and are presented in Appendix D. These measurements were reviewed by SwRI personnel in conjunction with the deposit ratings.

The major conclusions drawn in the SwRI report were:

- 1. No major engine failures occurred during the test program. The engines which were inspected were generally in acceptable condition. Based on engine condition, the two re-refined oils and the virgin-based oil were judged to have performed satisfactorily. In some cases the re-refined oils had better deposition performance than the virgin-based oil.
- 2. The observed difference in performance between the re-refined oils and the virgin oil could be either basestock effects and/ or additive package effects.

Table 10. Final mileages on the vehicles involved in the deposit ratings.

Vehicle Identification		
Matador Wagons	will were discandined by the low	2010 90 000 156 156
	BERC BERC BERC BOWN NO. MALADOR WAS AND THE BOWN DOING PRO PTO	
A17686	BERC	77101
A17685	MORCO	60174
A17687	MORCO	48285
117693	VIRGIN	49503
A17688	VIRGIN	54477
Dodgo Pickups		
A18731	MORCO	45091
A18710	MORCO	25617
A18716	VIRGIN	63910
A18729	VIRGIN	31940
Ford 750 Trucks		
A20369	MORCO	31576
A20371	VIRGIN	27207

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factorily. In some cases the te-refined oils had better deposi-

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ours and the virgin oil could be either basestock-affect

or additive package effects.

- 3. The MORCO oil had a tendency towards superior deposit control, but generally had higher oil consumption rates. It is recommended that the MORCO oil consumption be further investigated using a technique such as gas chromatographic boiling point distribution to determine if the higher oil consumption rate can be correlated to base oil volatility. Some of the vehicles inspected had rather brittle valve guide seals which could be contributing to oil consumption. The engine manufacturers (AMC, Ford, Dodge) should be contacted to determine if they have experienced any unusual valve guide seal problems.
- 4. Two AMC engines had a least one very heavily deposited intake valve which could cause engine problems in the future.
- 5. The wear measurements made by IDOT were reviewed. For the most part, the measurements tend to indicate that very little wear took place. Some notable exceptions were:
 - A20369 (F-750, MORCO) had three ring gaps which were excessive.
 - Two AMCs (MORCO) each had from one to three rings with rather high gap.
 - Two Dodges (VIRGIN oil) and one Dodge (MORCO) had some rather high exhaust valve guide wear.

The ring gap wear observed for the AMCs and the Ford F-750 using MORCO oil may have contributed to their higher oil consumption rates.

6. Overall, the results were very positive with respect to the field performance of the two lubricants made from re-refined components.

Pictorial documentation of representative piston skirts, intake valves, and intake valve lifters from selected engines is provided in Appendix C. Engine parts that rated (deposit rating) approximately the same as the vehicle's average were chosen.

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191777 distribution to determine if the higher oil consumptioning to

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28284 inspected had rather brittle valve guide scals which could be

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6. CONCLUSIONS

A comprehensive analysis of the Iowa Re-refined Oil Fleet Test was provided by SwRI. The major conclusions drawn in their report are provided in the Engine Inspection Results section. Although the analyses and conclusions that were derived are complete and sound, additional comments are appropriate.

Results from the boiling point distribution analyses of the three test oils indicated that the higher MORCO oil consumption rates were not caused by a larger fraction of light ends. Furthermore, AMC representatives emphasized that the use of nylon valve guide seals in their 360 in engines (used in the Matador wagons) were an improvement over previously used seals, and that there had been no reported problems with the newer product.

The VIRGIN oil used in this test may be underformulated with respect to the two re-refined oils. Evidence of inferior performance of the VIRGIN oil at an 8,000 mile ODI is based primarily on a total base number which approached zero on several occasions.

The 8,000 versus 10,000 mile oil drain interval tests on the Dodge vehicles were inconclusive. There were not enough vehicles with comparable mileage and performance. In switching the Matadors from 4,000 to 8,000 mile oil drain intervals, there was no obvious degradation of performance except for the low base reserve on the VIRGIN oil previously mentioned. Wear metal concentrations and oil consumption also increased at the 8,000 mile ODI, but not generally beyond acceptable levels. On the other hand, the VIRGIN oil viscosity in a significant number of

samples at the 8,000 mile ODI was unacceptably high. In these cases, severe oil degradation has occured.

When operating a fleet test there are several possible ways of selecting the oil. If several base stocks are purchased and a common additive package used, then the claim can be made that the additive package was inappropriate for one or more of the oils. If formulated oils are purchased, then the base stocks are not being directly tested. We chose the latter alternative because the Iowa DOT was interested in testing the commercially available MORCO product in comparison with the Virgin oil they had been purchasing on a low bid contract. In addition, the BERC oil was to be tested with a formulation that had performed satisfactorily in sequence tests. Our objective, therefore, was to compare oils which the supplier thought were properly formulated.

The variability in performance which one expects from fleet tests was also present here. Only two general conclusions are therefore offered:

- 1. There is need for a more meaningful or enforceable bid specification to ensure a minimum oil quality from bidders.
- 2. The re-refined oils generally performed at least as well as the Virgin oil.

A preliminary assessment of the feasibility of collecting waste oil in Iowa was made. Collection of oil from farms does not appear economically attractive. Collection from urban areas has been assessed by others and these results should apply in Iowa. The feasibility of collecting waste oil from state fleets or DOT garages has not been

adequately determined. The DOT is continuing to study the possibility of establishing a closed loop recycle system.

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7. RECOMMENDATIONS

This test has demonstrated that at least two re-refined oils perform satisfactorily in comparison with a virgin oil. These results
should be sufficient evidence for permitting re-refiners to bid for
fleet business along with virgin oil suppliers.

Continued efforts to develop methods for checking the quality and variability of re-refined products are warranted. These tests should also be applied to and be used for similar checks on virgin products; particularly from blenders where variability may be at least as large as for re-refined oil.

Resource conservation and environmental considerations would now seem to be even more compelling reasons for government to encourage recycling of waste oil. The Iowa DOT should continue evaluation of a closed loop recycle system for state vehicles. State operation of recycling centers at each of its garages may be another way to encourage recycling.

Based on reasonable oil consumption rates and good performance on the sludge and varnish ratings, the Iowa DOT should move toward longer oil drain intervals which at least meet the new vehicle recommendations.

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Mr. Robert Pedall was particularly helpful.

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This appendix contains of drain sample laboratory data from the fleet test vehicles. Information regarding the vehicle's specified of lived interval, initial test milesge and date, and type of test oil used the reported. In addition to the data from laboratory analyses, the matter milesge and date of oil drain sample are shown. Listed below the laboratory data are the milesges and quentities of oil added during the

APPENDIX A

OIL DRAIN SAMPLE ANALYSES

This appendix contains oil drain sample laboratory data from the fleet test vehicles. Information regarding the vehicle's specified oil drain interval, initial test mileage and date, and type of test oil used are reported. In addition to the data from laboratory analyses, the vehicle mileage and date of oil drain sample are shown. Listed below the laboratory data are the mileages and quantities of oil added during the drain interval.

A PERMITS A

DIE DRAIM SAMPLE ANALYSES

VEHICLE #A16938 Drain Interval: 4,000

Initial Test Mileage: 19,089 on 8/24/76

Test Oil: MORCO

	ileage Date	22,966 11/10/76	27,272 2/7/77	32,941 5/20/77	43,514 11/23/77
Flash °F		405	350	380	410
Viscosity	, SSU @ 100°F	380	368	401	430
	, SSU @ 210°F	63.22	63.41	64.64	67.37
V.I.		124	127	124	125
Benzene Ir	nsol.	0.01	0.33	0.20	0.08
Pentane Ir	nsol.	0.03	0.38	0.28	0.35
T.A.N.		4.45	3.94	4.24	4.44
T.B.N.		2.12	1.87	1.54	1.04
Anti-freez		neg.	neg.	trace	neg.
Fuel Dilut	tion	0.1%	0.5%	0.0%	0.2%
Ag	. 0	0	0	0	0
Na		18	18	17	16
Zn		1000	1200	1200	1100
Cu		12	6	. 4	4
A1		13	27	14	21
Ba		. 60	90	100	78
Ni		0	2	5	1
Cr		4	17	10	8
Ca		1200	1400	2300	1800
Fe		32	50	54	50
Si		8	15	9	12
Sn		13	23	10	11
Pb		55	90	110	120
P	★ 60. 35	750	1000	820	950
В		3	1	1	0
Mg		800	450	580	950
V		1	5	5	9
Mo		Ô	1	1	0
Mn		8	7	85	260
Cd		3	2	3	3
Ti		0	2	1	ő

VEHICLE #A16947 Drain Interval: 4,000 Initial Test Mileage: 26,472 on 8/11/76 Test Oil: VIRGIN

Mileage Date	30,805 10/28/76	34,311 3/17/77	38,403 5/31/77	45,856 8/29/77	50,331 10/27/77	62,730 4/4/78
Flash °F	405	345	390	415	425	380
Viscosity, SSU @ 100°F	333	325	351	444	437	422
Viscosity, SSU @ 210°F	60.26	59.54	60.83	68.96	66.46	66.20
v.1.	127	127	123	126	121	123
Benzene Insol.	<0.01	0.02	<0.01	0.02	0.01	0.02
Pentane Insol.	<0.01	0.04	0.01	0.03	0.02	0.03
T.A.N.	2.76	3.41	3.77	3.15	3.69	3.58
T.B.N.	1.63	1.49	1.60	0.57	1.31	1.88
Anti-freeze	neg.	neg.	neg.	neg.	trace	trace
Fuel Dilution	0.5%	0.4%	0.4%	0.5%	0.4%	0.8%
	1					
Ag	0	0	0	0	0	0
Na	20	3	14	9	18	20
Zn ager Briogree	820	1000	970	900	1100	1000
Cu	11	4	3	4	5	4
AI	13	19	11	22	18	13
Ва	65	110	100	110	110 B	82
Ni Cr	1	3	3	0	1	1
CI	8	16	11	19	8	10
Ca Rentant Insol.	1700	1500	2300	1500	2700	1800
Fe	54	88 20	38 10	0.30 57 13	53	48
51	11	18	10	13	10 12	9 7
Sn	210	110	14 900	24 140	110	7 74
bp . Vigeosity, 585	660	750	550	650	850	760
Y E	10	6		0 0		
	36	150	43	21	30	32 450
Mg V	2	0	230 6	300 8	2	5
Mo	0	i	1	2	0	. 0
Mn 90 E9	7	9	50	2150/33 210	280	320
Cd		4	2	7	2	1
T1	2	0	0	0	ō	0

Oil Additions/Mi 1 qt/28,682

VEHICLE #A16955 Drain Interval: 4,000 Initial Test Mileage: 16,196 on 8/10/76 Test Oil: VIRGIN

Mileage Date	20,494 12/13/76	31,868 9/2/77	36,132 3/27/78
Flash ^O F	410	395	435
Viscosity, SSU @ 100°F	370	473	426
Viscosity, SSU @ 210°F	62.08	69.71	65.06
V.I.	123	122	119
Benzene Insol.	<0.01	0.1	0.04
Pentane Insol.	0.01	0.2	0.05
T.A.N.	4.70	3.25	3.10
T.B.N.	1.48	1.61	1.58
Anti-freeze	neg.	trace	trace
Fuel Dilution	0.3%	0.0%	0.8%
Ag	0	0	0
Na	25	3	22
Zn	800	1000	900
Cu	13	5	6
A1	23	25	47
Ва	70	120	74
Ni	0	1	3
Cr	11	16	22
Ca	2100	2100	2600
Fe	98	61	230
Si	18	16	31
Sn	13	29	
Pb	75	140	140
P	630	760	980
В	8	5	2
Mg	35	0	28
V	3	10	4
Мо	1	2	1
Mn	22	180	420
Cd	2	9	4
Ti	3	0	2

VEHICLE #A16964 Drain Interval: 4,000 Initial Test Mileage: 27,866 on 8/11/76 Test Oil: MORCO

Mileage Date	32,256 11/1/76	37,420 6/14/77	48,975 12/21/77			
Flash OF	395	380	420		3,45%	
liscosity, SSU @ 100°F	361	400	415			
iscosity, SSU @ 210°F	62.64	65.40	65.91			
/.I.	127	126	124			
Benzene Insol.	<0.01	0.42	0.25			
Pentane Insol.	0.02	0.49	0.28			
r.A.N.	3.89	4.38	3.55			
r.B.N.	1.69	0.94	1.61			
inti-freeze	neg.	neg.	trace			
Tuel Dilution	0.4%	0.2%	0.3%			
der brideren	0.4%	0.2%	0.3%		,	
in the second	0	0	0			
Ag Na	21	25	30			
Zn	1100	1200	1000			
Cu	12	4	4			
	14	16	20			
A1						
Ва	65	89	90			
Ni	0	2	5			
Cr	6	12	6			
Ca	1600	2500	1800			
Fe	45	120	54			
Si	10	13	12			
Sn	2.00	16	10			
Pb	68	110	80			
P	1000	950	800			
В	3	0	0			
Mg	600	820	650			
V	4	3	5			
Мо	0	0	0			
Mn	9	65	240			
Cd	4 4	品图 8 成四3 下 5 出 1 型	7			
Ti	1	1	0			

VEHICLE #A17015 Drain Interval 4,000 Initial Test Mileage: 24,160 on 8/24/76 Test Oil: MORCO

Aiscosity, SSU @ 100°F 368 359 366 437 465 500 fiscosity, SSU @ 210°F 63.43 61.88 62.60 68.49 69.89 71.78 71	Mileage Date	28,296 10/8/76	32,939 12/27/76	37,153 4/4/77	41,434 6/2/77	46,053 8/17/77	50,384 10/20/77
## ## ## ## ## ## ## ## ## ## ## ## ##	Flash OF	365	375	420	405	405	425
## ## ## ## ## ## ## ## ## ## ## ## ##	Viscosity, SSU @ 100°F	368	359	366	437	465	500
TI. 127 126 126 126 126 126 124 123 enzene Insol.	Viscosity, SSU @ 210°F	63.43	61.88	62.60	68.49	69.89	71.78
enzene Insol.				126			
entane Insol.			20	12	0.07		
A.N.							
.A.N. 4.12 5.36 4.14 3.73 4.61 3.10 .B.N. 1.51 1.42 0.83 1.27 1.54 1.94 nti-freeze neg. neg. neg. neg. neg. neg. neg. trace uel Dilution 0.5% 0.7% 0.7% 0.4% nil 0.4% 0.37 Ag 0 0 0 0 0 0 0 0 0 0 0 0 Na 20 35 15 15 15 12 15 Zn 1100 1100 1100 1300 1100 1100 1300 Cu 11 7 5 5 5 5 5 5 4 All 7 21 23 17 10 23 Ba 60 65 120 110 85 99 Ni 3 4 0 0 7 3 3 2 Cr 7 7 13 20 15 19 13 Ca 1800 1700 1600 2500 1500 1500 1900 Fe 26 82 82 82 48 41 58 Si 7 15 14 11 9 13 Sn 12 20 18 20 14 15 Fb 70 90 170 180 180 180 88 P 450 1000 990 1100 850 900 B 3 3 2 2 2 1 1 0 90 MM 590 500 520 250 800 700 450 V 4 3 6 6 6 6 4 4 4 MM 14 34 27 120 180 290 MM 0 0 1 1 0 1 0 1 0 1 100 850 900 V 4 3 6 6 6 6 4 4 4 MM 14 34 27 120 180 290 Cd 4 4 5 2 2 9 9 5 5 4 MM 14 34 27 120 180 290 Cd 4 4 5 2 9 9 5 5 4 MM 14 34 27 120 180 290 Cd 4 4 5 2 9 9 5 5 4 Ti Additions/Mi 1 4 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, Lately and the second	La company of the com	0.01	1.29		3800		
nti-freeze neg. neg. neg. neg. neg. neg. trace nel Dilution	T.A.N.	4.12	5.36	4.14	3.73	4.61	3.10
nti-freeze neg. neg. neg. neg. neg. neg. neg. neg	T.B.N.	1.51	1.42	0.83		1.54	1.94
Ag 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Anti-freeze	neg.		neg.		neg.	trace
Ag 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Fuel Dilution		0.7%		nil .	0.4%	0.3%
Ag 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0							
Na 20 35 15 15 15 12 15 2n 15 2n 1100 1100 1100 1300 1100 1100 1100 1000 1000 1000 1000 1100 1100 1100 1000 1000 1000 1100 1000 1000 1000 1100 1000 1000 1000 1100 100	Ag	0	0 .		0	0	. 0
Cu 11 7 21 23 17 10 23 84 17 10 23 84 17 10 23 84 17 10 23 84 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 10 85 90 81 17 18 18 19 13 18 19 13 18 18 18 18 18 18 18 18 18 18 18 18 18				15			
Cu	Zn	1100	1100		1300	1100	1100
Ba 60 65 120 110 85 90 Ni 3 4 0 7 3 2 Cr 7 13 20 15 19 13 Ca 1800 1700 1600 2500 1500 1900 Fe 26 82 82 48 41 58 Si 7 15 14 11 9 13 Sn 12 20 18 20 14 15 Pb 70 90 170 180 180 88 P 450 1000 900 1100 850 900 B 3 2 2 1 0 0 Mg 500 520 250 800 700 450 V 4 3 6 6 4 4 Mo 0 1 0 1 2 1 Mo 0 1 2 2 9 5 4	Cu	11		,	5		4
Ni 3 4 0 7 3 3 2 Cr 7 13 20 15 19 13 13 20 15 19 1900 Fe 26 82 82 82 48 41 58 51 7 15 14 11 9 13 58 51 7 15 14 11 9 13 58 70 90 170 180 180 180 88 P 450 1000 900 1100 850 900 Mg 500 500 520 250 800 700 450 V 4 3 6 6 6 4 4 4 4 Mn 1 1 0 0 1 1 2 1 Mn 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	A1				17		
Cr							
Ca 1800 1700 1600 2500 1500 1900 Fe 26 82 82 48 41 58 Si 7 15 14 11 9 13 Sn 12 20 18 20 14 11 9 13 Sn 70 90 170 180 180 180 88 P 450 1000 900 1100 850 900 B 3 2 2 2 1 0 0 0 Mg 5000 520 250 800 700 450 V 4 3 6 6 6 4 4 4 MO 0 1 1 0 1 0 1 2 1 Mn 14 34 27 120 180 290 Cd 4 5 5 2 9 5 4 Ti 2 7 120 180 290 Il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,		,	-	ŭ	,		
Fe 26 82 82 48 41 58 51 7 15 14 11 9 13							
Fe 26 82 82 48 41 58 51 7 15 14 11 9 13 58 51 7 15 14 11 1 9 13 58 70 90 170 180 180 88 P 450 1000 900 1100 850 900 16							
Sn 12 20 18 20 14 15 Pb 70 90 170 180 180 88 P 450 1000 900 1100 850 900 B 3 2 2 1 1 0 0 0 Mg 500 520 250 800 700 450 V 4 3 6 6 6 4 4 4 Mo 0 1 1 0 1 0 1 2 1 Mn 14 34 27 120 180 290 Cd 4 5 5 2 9 5 4 Ti 2 2 2 0 1 1 1 il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,	Fe	20		7.7			
Pb 70 90 170 180 180 88 P 450 1000 900 1100 850 900 B 3 2 2 1 1 0 0 0 Mg 500 520 250 800 700 450 V 4 3 6 6 6 4 4 4 Mo 0 1 1 0 1 2 1 Mn 14 34 27 120 180 290 Cd 4 5 2 9 5 4 Ti 2 2 2 0 1 1 1 11 Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,							
P 450 1000 900 1100 850 900 B 3 2 2 1 1 0 0 0 Mg 500 520 250 800 700 450 V 4 3 3 6 6 6 6 4 4 4 Mo 0 1 1 0 1 0 1 2 1 Mn 14 34 27 120 180 290 Cd 4 5 2 9 5 2 9 5 4 Ti 2 2 1 1 1 0 1 1 1 1 11 Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,							
B 3 2 2 2 1 0 0 0 0 Mg 500 520 520 800 700 450 450 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		, ,	, .	2,0			
Mg 500 520 250 800 700 450 V 4 3 6 6 6 4 4 4 4 4 4 6 6 6 7 4 4 4 6 7 6 6 6 7 4 6 7 6 7							
The control of the co							
Mo 0 1 0 1 0 1 2 1 Mm 14 34 27 120 180 290 Cd 4 5 2 9 5 4 Ti 2 2 2 0 1 1 1 1 il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,		300					
Mn 14 34 27 120 180 290 Cd 4 5 2 9 5 4 Ti 2 2 2 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1							
Cd							
Ti 2 2 0 1 1 1 1 il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46,							
il Additions/Mi							
il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,	. 11		2	0			ļ
il Additions/Mi 1 qt/26,545 1 qt/30,115 1 qt/34,624 1 qt/39,050 1 qt/43,564 1 qt/46, 1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,							
1 qt/28,206 1 qt/32,259 1 qt/36,621 1 qt/40,844 1 qt/45,030 1 qt/48,	il Additions/Mi		1 at/30.115	1 at/34.624	1 gt/39.050	1 at/43.564	1 at/46.9
	AAA 700 8 40 1203.4				-		
		1 40,20,200	- de/25,52)	1 40,50,021	- 40,000	1 40,45,050	

VEHICLE #A17029 Drain Interval: 4,000

Initial Test Mileage: 21,236 on 8/11/76 Test Oil: VIRGIN

Mileage Date	25,391 12/13/76	31,030 7/1/77	41,290 1/13/78	46,341 4/14/78		
Flash °F .	375	380	380	380	7	
Viscosity, SSU @ 100°F	338	408	494	469		
Viscosity, SSU @ 210°F	59.98	64.58	73.01	71.52		
v.I.	125	122	126	127		
Benzene Insol.	0.03	<0.01	0.95	0.04		
Pentane Insol.	0.05	0.01	2.20	0.06		
T.A.N.	4.88	2.94	3.68	4.46		
T.B.N.	1.33	1.43	1.78	1.94		
Anti-freeze	neg.	neg.	present	present		
Fuel Dilution	0.4%	0	0.2%	1.2%		
	1150					
Ag	0	0	0	0		100
Na	30	25	20	27		,
Zn	800	880	1200	1200		
Cu	18	13	8	5		
A1	28	56	26	12		
Ва	70	88	100	100		
Ni	0	1	2	1.33		
Cr	17	30	13	7		
Ca	2000	2300	1900	3400		
Fe	140	200	76			
Si	25	39	18	12		
Sn	17	20	13	9		
Pb	13	230	110	72		
P	660	600	950	1000		
В	7	7	5	3		
Mg	37	32	23	22		
V	3	2	5	6		
Mo	11	0	1	3		
Mn	8	76	240	250		
Cd	10/18/19 2	13/31/16	4	672/27 - 1		
Ti	2	0	01/122	41,434		

VEHICLE #A17030 Drain Interval: 4,000 Initial Test Mileage: 19,123 on 8/11/76 Test Oil: MORCO

Mileage Date	23,789 11/5/76	27,832 2/24/77	32,753 5/18/77	36,152 7/27/77	42,760 3/20/78	
lash °F	430	360	420	425	375	
iscosity, SSU @ 100°F	375	358	409	374	369	
Viscosity, SSU @ 210°F	62.75	62.57	65.09	63.83	63.76	
7.1.	124	128	123	127	128	
enzene Insol.	0.06	0.02	<0.01	0.09	0.31	
entane Insol.	0.53	0.04	<0.01	0.12	0.34	
.A.N.	4.32	3.84	5.85	4.14	5.00	
.B.N.	1.94	2.54	1.88	1.67	1.94	
nti-freeze	trace	trace	neg.	neg.	neg.	
uel Dilution	0.5%	0.4%	0.5%	0.3%	1.7%	
SET DITUETOR	0.40	900	100	7700	2.770	
A.o.	0	0	0	0	0	
Ag Na	23	7	25	15	17	
Zn	1100	1150	1300	1180	1100	
Cu ille insertent	13	6	4	5	5	
	13	17	11	10	28	
Ba	60	70	110	87	70	
Ni	1	6	6	1	4	
Cr	7	15	15	10	17	
Ca	1600	1500	2700	1700	2300	
Fe	56	100	47	31	120	
0:	11	15	9	8	19	
Sn Sn	19	26	21	15		
Pb	60	58	140	120	540	
277						
Packet ch' gen o 3/011	1050	1100	1100	800	1400	
B Me	2	3	1	0	0	
1.6	800	540	630	200	700	
V	4 000	6	7 1140	5	6	
Мо	0	2	1		4	
Mn	8	10	89	92	390	
cu	3	3	5	4	6	
Ti	I and the second	2	2	0	2	

Oil Additions/Mi

1 qt/21,660

VEHICLE #A17035 Drain Interval: 4,000 Initial Test Mileage: 13,117 on 8/11/76 Test Oil: VIRGIN

Mileage Date	17,718 11/4/76	22,912 2/8/77	27,644 5/7/77	39,533 11/28/77		
Flash °F	405	310	400	385	7	
Viscosity, SSU @ 100°F	325	309	361	431		
Viscosity, SSU @ 210°F	58.18	57.48	60.89	67.12		
V.I.	122	124	122	123		
Benzene Insol.	<0.01	<0.01	<0.01	0.01		
Pentane Insol.	<0.01	0.01	<0.01	0.03		
T.A.N.	3.46	2.95	5.23	3.36		
T.B.N.	1.69	0.12	0.77	0.81		
Anti-freeze	neg.	neg.	neg.	present		
Fuel Dilution	0.5%	<0.10%	0.4%	0.8%		
	1700					
Ag	0	0	0	0		
Na	22	50	21	18		
Zn	840	800	950	1100		
Cu	15	6 4 5	5	5		/
A 1	11	13	8	18		
Ba	65	65	110	100		
Ni	7.30 -1 0	3.56 31 9	11 89 15	F 91 1 1		
Cr	3	8	8	6		
Ca	1400	1750	2300	1800		
Fe	47	80	<0 01 42	48		
Si	8	0 9 9	< 07 17 7 10	0 03 12		~
Sn	20	20	20	12		
Pb .	73	64	115	98		
court P 220 3 Sin L	500	650	530	900		
В	8	6	5	4		
Mg	35	35	27	37		
V	5	3	4	12		
Mo '	0	1	1	0		
Mn	7	6	88	200		
Cd	2	2/21/17/3	21,001,13,4	2		
Ti	1	51 635 2	235523 1	0		

Oil Additions/Mi

1 qt/15,610

1 qt/21,144

1 qt/17,215

Drain Interval: 4,000

Initial Test Mileage: 25,491 on 8/10/76 Test Oil: VIRGIN

Mileage Date	29,960 12/13/76	41,673 9/7/77	46,093 12/1/77	50,116 3/30/78		beg
Flash °F	425	410	375	375*	The second	7.1
Viscosity, SSU @ 100°F	321	586	442	369		
Viscosity, SSU @ 210°F	59.32	74.63	67.34	63.76		
V.I.	127	115	122	128		
Benzene Insol.	<0.01	0.2	0.01	0.31		
Pentane Insol.	0.01	0.3	0.02	0.34		
r.A.N.	2.07	3.44	4.07	5. 32. 10		
C.B.N.	1.78	0.30	1.07	1.94		
	1.76			1.94		
nti-freeze	neg.	neg.	present	neg.		
uel Dilution	1.2%	0.1%	0.3%	1.7%		
Ag	0 1900	0	0	0		
Na	25	5	19	13		
Zn	800	1000	1000	1000		
Cu	11	8	4	3		
A1	11	27	17	20		
ва	70	110	09	70		
Ni	0	1 27	1 8	2		
Cr Ca	2000	1300	1800	2600		
Fe	55	1300	1000	2000		
Si	9	100 17	56 11	76 12		
Sn	11	26	11	0103		
Pb	40	375	130	100		
P	660	750	870	1400		
В	9	19	2	5		
Mg		250	52	26		
V	33	8	9	5		
Mo	1	2	0	0 1 1 700		
Mn	•	212	000			
Cu	7 2	19	3	280		
Ti	2	0	ō	1		
11	THE THE CASE	13 (70) 30-	225 23 3 3	178743		

^{*}Foaming from 200-340°F

Drain Interval: 4,000 Initial Test Mileage: 24,557 on 8/12/76 Test Oil: MORCO

Mileage Date	30,331 10/14/76	34,316 12/16/76	38,770 4/1/77	42,947 7/8/77	47,890 9/30/77
Flash °F	405	405	. 380	390	390
Viscosity, SSU @ 100°F	478	410	340	400	397
Viscosity, SSU @ 210°F	70.71	68.65	61.17	65.55	64.56
V.I.	123	124	128	126	124
Benzene Insol.	0.01	0.03	0.02	0.01	0.01
Pentane Insol.	0.03	0.17	0.03	0.02	0.02
r.A.N.	4.62	6.05	3.80	3.26	2.74
r.B.N.	1.88	1.42	2.10	2.73	2.69
Anti-freeze	neg.	neg.	neg.	neg.	present
uel Dilution	1.0%	1.6%	0.4%	0.1%	0.2%
Ag	800 0	0	0	0	0
Na	220	250	145	150	85
Zn	1300	1200	1100	1100	1100
Cu	15	8	4	11	5
A1	16	22	16	11	1 =
Ва	80	70	95	100	90
Ni	1968	2	braseurs in 3	2	0
Cr	8	10	14	12	11
Ca	1300	1600	1500	1800	1900
Fe	45	80	63	38	35
Si	16	. 19	13	10	10
Sn	8.01 97	25	13	14	7
Pb	80	75	56	88	90
P	1140	950	500	750	850
В	24	29	7.83	12	17
Mg	600	450	380	550	650
V	2	4	8	8	4
Mo	337 35 0	1	0	0	0
Mn	8	41	12	110	140
Cd	4	4	1	5	6
Ti	1213131	0.1	3	1/36/128	Ö

1 qt/26,859

Oil Additions/Mi

1 qt/28,341

1 qt/--

1 qt/28,691

1 qt/32,437

VEHICLE #A17677 Drain Interval: 4,000; 8,000 Initial Vehicle Mileage: 2,773 on 8/2/76 Test Oil: MORCO

Mileage Date	7,490 9/28/76	11,704 12/10/76	15,053 2/24/77	23,300 6/22/77	31,072 10/27/77	40,883 5/10/78
Flash, ^O F	390	370	395	420	390	365
Viscosity, SSU @ 100°F	407	354	338	356	395	498
Viscosity, SSU @ 210°F	64.34	60.61	59.84	60.70	64.36	69.9
V.I.	121	122	124	123	124	118
Benzene Insol.	< 0.01	< 0.01	0.05	0.26	0.4	2.24
Pentane Insol.	0.01	0.01	0.13	0.30	0.74	2.39
T.A.N.	5.32	4.84	3.76	3.32	3.73	6.32
T.B.N.	1.39	3.90	2.59	1.32	2.03	0.58
Anti-freeze	neg.	neg.	trace	neg.	neg.	present
Fuel Dilution	0.8%	2.4%	0.8%	0.4%	0.2%	0.8%
54	30	33	40	90	ful Francisco	34 - 15511 4
100	24	2.4	2	40		
Ag Na	0	0 30	0.3	0 25	0 35	0 38
Zn	1,100	1,100	1,200	1,000	3,350	2,800
Cu	32	21	8	3	7	8
A1	20	22	18	14	22	25
Ba	70	65	90	60	100	80
Ni	5	0	6	1	0	3
Cr	5	6	8	1	4	11
Ca	2,000	1,800	1,300	1,200	2,300	2,600
Fe	70	85	95	60	90	320
Si	25	19	16	6	18	27
Sn	35	15	25	1	21	14
Pb	120	100	80	150	140	130
P	500	900	1,100	600	1,000	1,400
В	3	1	3	0	0	3
Mg	550	480	540	450	1,150	750
V Mo	6	3 8	6 5 1 P	0 3	4 9	3 17
Mn	10	9	9	110	650	1,050
Cd	1	0	1	0	0	0
Ti	3	2	2	0	Ö	Ō
		1771		1 417 005	11 12 106 222	market 122 222
He leave	1,083	1 qt/ 9,100	70,735	1 qt/17,896	1 qt/26,330	1 qt/33,220
Oil additions/Mi	1 qt/4,100	1 qt/10,921	1 qt/13,199	1 qt/19,900	1 qt/27,050	1 qt/35,177
				1 qt/21,262	1 qt/29,570	1 qt/36,438
Control to the Control of the Contro					1 qt/29,990	

VEHICLE #A17678
Drain Interval: 4,000; 8,000
Initial Test Mileage: 2,776 on 8/9/76
Test Oil: VIRGIN

					2 At 12 754	a detra time	 7 45	32 0.00		11/12/11/2
Mileage Date	7,051 9/29/76		1,078 /18/76	14,793 1/19/77	18,392 3/16/77	25,999 7/26/77	31,525 11/15/77	26,330	39,729 3/31/78	45,033 6/19/7
Flash, °F	380		380	270	410	385	 375	- Q	400	390
Viscosity, SSU @ 100°F	347		332	283	388	646	618		988	488
Viscosity, SSU @ 210°F	60.74	. 5	9.30	56.50	63.20	79.97	79.14		97.66	69.24
V.I.	124		124	129	123	117	119		111	119
Benzene Insol.	<0.01	<	0.01	0.10	0.01	< 0.01	0.01		0.22	0.05
Pentane Insol.	< 0.01		0.01	0.20	0.02	0.01	0.02		0.43	0.07
r.A.N.	3.05		3.63	4.02	4.23	7.32	4.17		5.67	3.31
r.B.N.	0.67		0.54	0.30	0.66	0.12	0.36		0.0	1.04
Anti-freeze	neg.		neg.	neg.	neg.	neg.	neg.		neg.	neg.
Fuel Dilution	0.6%		0.4%	1.6%	0%	0.9%	0.3%		0.8%	0.7%
pH	0.0%		0.4%	1.0%	0%	0.9%	0.5%		4.0	0.7%
рн						24				
Ag	0	1004	0	0	0	0	0		0	0
Na	50 .		30	65	9	46	50		94	54
Zn	800		800	900	950	1,000	900		980	920
Cu	37		23	14	11	20	24		23	/ 8
A1	56		24	27	23	59	51		72	29
Ва	90		70	90	110	80	100		94	98
Ni	3		1	4	01 65 4	4	0		5	2
	5		_		,	14			20	6
Cr			5	12						
Ca	2,000	2	,000	1,800	1,500	1,600	2,200		2,700	1,500
Fe	125		95	140	110	140	150		440	170
Si	13		13	13	12	20	22		30	17
Sn	30		25	23	21	27	25		19	30
Pb	40		50	68	78	160	90		130	65
	280		700		100		700		960	780
P			700	700	600	700				
В	15		8	5	5	3	8		23	17
Mg	15		33	30	22	18	22		22	14
V	4		2	_ 4	0	5	5		4	8
Mo	10		2	7	8	13	11		21.	10
	9				11	370	750		1,150	750
Mn			9	8						
Cd	1		0	0	2	3	0		1	0
Ti	2		1	5	0	0	0		1	0

		1 qt/8,000			1 qt/20,108	
Oil additions/Mi	1 qt/5,218	1 qt/9,665	1 qt/12,268	1 qt/16,748	1 qt/21,207	1 qt/35,000

Drain Interval: 4,000

Initial Vehicle Mileage: 1,516 on 8/2/76

Test Oil: MORCO

Viscosity, SSU @ 100°F	Mileage Date		5,728 2/7/77	15,556 8/26/77
Viscosity, SSU @ 210°F 61.28 67.26 V.I. 125 120 Benzene Insol. 0.02 0.88 Pentane Insol. 0.04 1.24 T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mg 500 1,000 V 3 10 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97	Flash, °F	5,798 	365	380
Viscosity, SSU @ 210°F 61.28 67.26 V.I. 125 120 Benzene Insol. 0.02 0.88 Pentane Insol. 0.04 1.24 T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mg 500 1,000 V 3 10 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97	Viscosity, SSU @	100 ⁰ F	353	452
V.I. 125 120 Benzene Insol. 0.02 0.88 Pentane Insol. 0.04 1.24 T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mg 500 1,000 V 3 10 Mn 12 300 Cd 1 1 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 I qt/5,699 1 qt/11,84			61.28	67.26
Benzene Insol. 0.02 0.88 Pentane Insol. 0.04 1.24 T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mm 12 300 Cd 1 3 Ti 2			125	120
Pentane Insol. T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 80 Cr 11 12 Ca 1,800 1,300 Fe 80 Si 32 26 Sn Pb 80 130 Pb 80 130 Pb 80 150 P 1,000 Ra 10 No 10 11 Mn 12 300 Cd 11 3 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
T.A.N. 3.38 5.26 T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 122 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
T.B.N. 1.21 1.56 Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97				
Anti-freeze trace neg. Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84	T.A.N.		3.38	5.26
Fuel Dilution 0.4% 0.1% Ag 0 0 0 Na 20 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 I qt/5,699 1 qt/11,844	T.B.N.		1.21	1.56
Ag 0 0 12 Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 30 Cd 1 3 300 Cd 1 4 3 300 Cd 1 3 300 Cd 1 4 3 300 Cd 1 3 300 Cd 1 4 4 5 5 699 Cd 1 4 4 5 6 6 6 6 699 Cd 1 4 4 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	Anti-freeze		trace	neg.
Na 20 12 Zn 1,100 1,000 Cu 21 17 A1 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 1,000 V 3 1 0 Mg 500 1,000 V 3 10 Mn 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 I qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97	Fuel Dilution	ns/9t	0.4%	0.1%
Na 20 12 Zn 1,100 1,000 Cu 21 17 A1 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 1,000 V 3 1 0 Mg 500 1,000 V 3 10 Mn 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 I qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97			profession of	174
Zn 1,100 1,000 Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 Ti 2 0 Oil additions/Mi 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Cu 21 17 Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 30 Cd 1 3 300 Cd 1 3 300 Cd 1 300 Cd 1 3 300 Cd 1 37 Cd 1 47/3,825 1 qt/9,97 Oil additions/Mi 1 qt/3,825 1 qt/9,97				
Al 26 23 Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 10 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97				
Ba 70 80 Ni 5 8 Cr 11 12 Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 Ti 2 0 Oil additions/Mi 1 qt/2,787 1 qt/9,97 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Cr				
Ca 1,800 1,300 Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84	Ni		5	8
Fe 80 180 Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84	Cr		11	
Si 32 26 Sn 45 30 Pb 80 150 P 1,000 700 B 1 0 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84	Ca		1,800	1,300
Sn 45 30 Pb 80 150 P 1,000 700 B 1,000 1,000 V 3 10 Mo 10 11 Mm 12 300 Cd 1 3 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				180
Pb 80 150 P 1,000 700 B 1,000 10 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 3 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
P 1,000 700 B 1 0 Mg 500 1,000 V 3 10 Mo 10 11 Mn 12 300 Cd 1 3 Ti 2 0 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
B 1 0 1,000 V 3 100 1,000 V 3 10 11 Mm 12 300 Cd 1 3 2 0 0 1				
Mg 500 1,000 V 3 10 Mo 10 11 Mm 12 300 Cd 1 3 Ti 2 0 Oil additions/Mi 1 qt/2,787 1 qt/9,19 1 qt/5,699 1 qt/11,84				
V 3 10 Mo 10 11 Mm 12 300 Cd 1 3 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Mo 10 11 Mm 12 300 Cd 1 3 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Mm 12 300 Cd 1 3 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Cd 1 3 0 Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Ti 2 0 1 qt/2,787 1 qt/9,19 Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84				
Oil additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84	191			
0il additions/Mi 1 qt/3,825 1 qt/9,97 1 qt/5,699 1 qt/11,84		59 1	1 qt/2,787	1 qt/ 9,19
	Oil additions/Mi			1 qt/ 9,97
1 qt/14,00			1 qt/5,699	1 qt/11,84
				1 qt/14,00

VEHICLE #A17680 Drain Interval: 4,000; 8,000 Initial Vehicle Mileage: 3,074 on 7/26/76 Test Oil: BERC

Mileage Date	7,605 9/11/76	11,530 11/5/76	15,370 2/11/77	23,383 5/25/77	31,537 9/29/77	39,375 1/18/78	45,887 4/26/78
Flash, ^O F	410	380	430	380	385	360	440
Viscosity, SSU @ 100°F	375	380	373	460	472	437	423
Viscosity, SSU @ 210°F	62.42	63.38	63.22	66.71	68.52	67.25	65.8
V.I.	123	124	126	117	119	123	122
Benzene Insol.	< 0.01	<0.01	0.01	1.30	0.211	0.63	1.10
Centane Insol.	.<0.01	0.03	0.03	2.28	0.124	0.21	1.95
r.a.n.	3.29	3.89	3.50	3.53	5.05	3.90	4.84
r.B.N.	1.33	2.18	1.38	1.38	0.72	0.97	0.52
Anti-freeze	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Fuel Dilution	0.8%	0.3%	0.2%	0.4%	0.2%	0.8%	0.7%
Ag	0	0	0	0	0	0	, 0
Na	15	25	10	0	3	65	50
Zn	950	950	930	1,100	850	900	980
Cu	3	12	6	5	5	12	15
Al	15	19	21	28	35	74	60
Ba	. 80	90	100	150	110	97	95
			3	9	0	4	3
Ni	2	2					
Cr	1	4	8	12	9	13	10
Ca	2,800	2,100	2,800	4,300	2,200	2,400	2,700
Fe	58	72	100	190	250	300	350
Si	15	14	15	19	18	33	32
Sn	15	30	33	32	36	23	16
Pb	52	55	54	150	160	110	90
P	650	500	800	800	650	825	770
В	0	2	3	4	4	16	9
Mg	11	17	17	. 22	22	20	14
v	1 < 2 = 1	8 6 6 W W C C 2 N C	3	7	10	4	4
Мо	2	5	7	10	11	11	12
Mn	1	7	5	200	520	850	700
		0	0	1	3	1	700
Cd	0		,		1	1	
Ti	0	1	4	2	1	1	0

1 qt/4,679 . 1 qt/19,270 1 qt/28,213

Oil additions/Mi 1 qt/7,052 1 qt/14,335 1 qt/22,322 2 qt low 1 qt/37,028 @ change

VEHICLE #A17681 Drain Interval: 4,000 Initial Vehicle Mileage: 1,844 on 7/28/76 Test Oil: VIRGIN

Mileage Date	5,798 3/15/77	9,736 1/6/78	11,851 5/8/78
Flash, °F	405	360	370
Viscosity, SSU @ 100°F	328	339	354
Viscosity, SSU @ 210°F	59.04	59.88	62.43
V.I.	124	124	128
Benzene Insol.	6.01	0.01	0.02
Pentane Insol.	0.01	0.02	0.03
T.A.N.	4.20	399	3.24
T.B.N.	0.16	0	1.49
Anti-freeze	neg.	neg.	trace
Fuel Dilution	0.4%	0.8%	1.3%
рН		3.5	
Ag	0	0	0
Na	- 11 chage	32	20
Zn	900	760	1,150
Cu	8	9	7
A1	29	46	21
Ba	120	92	95
Ni	6	6	3
Cr	8	. 9	6
Ca	1,700	1,800	2,000
Fe	830	800	230
Si	33	33	16
Sn	32	22	15
Pb	37	82	40
P	700	650	980
В	10	10	4
Mg	17	15	16
V	0	4	6
Mo	11	14	8
Mn	12	210	210
Cd	2	2	0
Ti	0	1 1 1	0

1 qt/4,030

Oil additions/Mi

1 qt/4,551

Drain Interval: 4,000; 8,000 Initial Vehicle Mileage: 1,164 on 7/28/76 Test Oil: MORCO

Mileage Date	5,428 10/15/76	9,674 1/18/77	16,947 6/9/77		26,565 11/17/77	33,292 3/15/78	36,106 5/5/78
Flash, °F	400	360	 405	6 14	395	370	390
Viscosity, SSU @ 100°F	366	363	456		421	367	353
Viscosity, SSU @ 210°F	62.69	61.67	67.59		66.33	63.1	62.6
V.I.	126	123	120		124	127	129
Benzene Insol.	<0.01	0.79	0.65		0.15	0.25	0.02
Pentane Insol.	<0.01	1.19	0.78		0.66	0.26	0.03
T.A.N.	4.51	4.23	5.61		4.30	4.05	3.58
T.B.N.	1.75	0.79	0.72		1.55	1.75	1.68
Anti-freeze	neg.	neg.	neg.		neg.	trace	neg.
Fuel Dilution	0.4%	0.7%	0		0.2%	1.2%	0.4%
Ag	0	0	0		0	0 /	0
Na	32	57	20		25	17	17
Zn	1,100	1,150	1,200		1,200	1,000	1,100
Cu	17	11	5		6	3	2
A1	17	19	18		34	21	16
Ba O I I I I O O O	60	70	90		95	68	76
N1		4	2		0	1	1
Cr	4	7	5		4	6	4
Ca	2,000	2,000	2,500		2,900	2,700	2,400
Fe Si	60	185 20	210 18		130 19	130 15	58 11
Sn	15 30	33	20		20	20	9
Pb	35	45	150		95	50	39
P	480	900	1,000		920	1,300	980
В	2	2	0		0	0	0
Mg	500	440	850		1,100	850	650
V	3	3	2		4	2	5
Mo	3	11	10		10	8	4
Mn	8	11	120		340	360	210
Cd	1	0	2		0	0	0
Ti	3	2	0		0	2	0
	1 qt/3,280	1 qt/6,119	1 qt/10,974		1 qt/18,406	1 qt/27,421	2 qt/34,275
Oil additions/Mi	1 qt/4,766	1 qt/7,786	1 qt/12,352		2 qt/20,041	1 qt/28,493	1 qt/35,305
off additions/Pit	The state of the s	1 qt/9,638	1 qt/13,113		2 qt/21,844	2 qt/30,542	1 qt/36,005
		1 qt/9,030			No. 10. 15. 15.		1 qt/36,003
			1 qt/15,532		1 qt/22,887	2 qt/32,086	
					2 qt/25,687	1 qt/32,944	

VEHICLE #A17683 Drain Interval: 4,000; 8,000 Initial Vehicle Mileage: 3,144 on 7/12/76 Test Oil: VIRGIN

Mileage Date	7,075 9/10/76	11,076 10/18/76	15,336 12/7/76	19,204 1/26/77	23,345 3/21/77	31,635 8/9/77	39,310 11/18/77	46,945 3/17/78	49,503 4/24/78
Flash, ^o F	. 410	355	405	405	400	405	225	310	385
Viscosity, SSU @ 100°F	421	378	396	403	432	435	359	466	412
Viscosity, SSU @ 210°F	66.69	63.91	64.25	64.30	66.29	65.38	63.00	72.74	66.44
V.I.	124	127	128	122	122	118	129	130	127
Benzene Insol.	< 0.01	< 0.01	< 0.01	0.01	0.01	0.01	0.05	0.24	0.02
Pentane Insol.	<0.01	0.01	0.01	0.02	0.03	0.02	0.08	0.30	0.03
T.A.N.	3.72	3.36	2.12	3.16	3.37	3.14	2.34	4.07	4.39
T.B.N.	1.63	1.33	2.30	0.91	0.50	0.59	1.61	2.13	1.68
Anti-freeze	neg.	neg.	neg.	neg.	trace	trace	trace	trace	present
Fuel Dilution	0.2%	0.5%	1.2%	0.4%	0.4%	0.7%	2.0%	2.0%	1.4%
Fire Pt. °F							415	410*	
Ag Na Zn Cu Al Ba Ni Cr Ca Fe	0 27 1,000 12 12 80 1 4 1,700	0 32 900 13 10 70 2 5 2,200	0 23 900 10 13 65 1 4 2,400	0 70 980 4 18 100 2 8 1,900	0 4 980 4 17 110 1 6 1,900 100	0 20 1,000 4 28 130 0 11 1,600	0 50 3,750 5 28 115 0 15 2,900 100	0 46 1,500 7 34 88 4 11 2,600 230	0 32 1,150 3 18 95 2 5 2,400
Si Sn Pb P B	11 40 870 3	14 30 50 350 3	12 21 35 780	13 25 75 800 3	13 25 90 850 6	16 35 240 750 10	15 20 125 900 8	18 23 120 1,250 16	12 13 47 880 14
Mg V Mo Mn	13 5 3 15	16 4 4 30	13 1 4 17	17 4 7 12	17 0 5 58	56 9 9 180	29 7 7 270	5 10 370	18 5 6 150
Cd Ti	1 2	1 3	1 2	1 2	1 2	5	0 0	0 2	0 0
	1 qt/3,144	1 qt/8,119	1 qt/12,219	1 qt/16,953		1 qt/25,540	1 qt/34,300	1 qt/41,462	
Oil additions/Mi	½ qt/4,675	1 qt/9,560	1 qt/14,076	1 qt/18,505	1 qt/21,111	1 qt/26,932	1 qt/35,410	1 qt/43,060	1 qt/48,874
	1 qt/6,225 1 qt/6,663					1 qt/30,090	1 qt/36,407 1 qt/37,673	1 qt/43,812 1 qt/45,320	*1
Bubbling around 190	3021 × 300			. *			1 qt/38,246	1 qt/46,800	

Drain Interval: 4,000; 8,000

Initial Vehicle Mileage: 2,022 on 8/2/76 Test Oil: VIRGIN

Mileage Date	5,897 9/23/76	10,005 11/30/76	14,057 2/25/77	23,763 8/2/77	32,346 12/21/77	40,562 5/15/78
Flash, °F	405	375		395	385	380
Viscosity, SSU @ 100°F	326	322		481	426	628
Viscosity, SSU @ 210°F	59.32	59.13		69.46	68.20	77.84
7.1.	126	126		120	127	116
Benzene Insol.	<0.01	< 0.01		0.01	0.11	0.34
Pentane Insol.	<0.01	< 0.01		0.03	0.24	0.93
C.A.N.	2.93	3.50		4.67	4.03	6.41
r.B.N.	0.61	0.80		0	0.24	0
inti-freeze		neg.		trace	neg.	neg.
	neg.			0.8%	0.9%	1.0%
Fuel Dilution pH	0.4%	0.7%			0.9%	
· ·				3.5	- 1 No. 1	3.8
Ag Na Zn Cu Al Ba Ni Cr Ca Fe Si Sn Pb P B Mg V Mo Mn Cd Ti	0 25 960 22 23 130 4 6 2,700 95 32 14 34 620 12 9 5	0 45 850 19 19 100 1 7 1,600 120 25 23 42 480 14 12 2		0 37 980 20 52 90 7 19 1,600 280 35 32 143 600 6 32 10 17 360	0 110 920 9 40 92 7 11 2,100 310 31 15 80 775 6 22 7 11 800 0	0 60 1,000 10 46 85 5 12 2,300 950 38 23 130 1,120 16 16 5 20 1,300 0
Dil additions/Mi	1 qt/3,033	1 qt/8,379 1 qt/7,117		1 qt/15,430 1 qt/17,891 1 qt/21,166	1 qt/25,990 1 qt/26,687 1 qt/27,298	1 qt/33,92

VEHICLE #A17685 Drain Interval: 4,000; 8,000 Initial Test Mileage: 3,151 on 7/27/76 Test Oil: MORCO

Mileage Date	7,262 9/1/76	11,212 10/12/76	16,160 12/1/77	21,377 2/9/77	29,459 5/6/77	37,756 8/9/77	45,350 10/26/77	50,057 1/25/78	60,174 4/24/78
Flash, °F	. 410	400	415	415	405	400	405	390	405
Viscosity, SSU @ 100°F	355	360	376	433	427	394	401	378	390
Viscosity, SSU @ 210°F	61.52	61.79	64.12	66.58	67.88	65.67	66.37	64.36	65.3
V.I.	125	124	127	0.22	127	0.28	0.28	128	128
Benzene Insol.	0.06	< 0.01	0.14	0.39	0.02	0.02	0.26	0.07	0.13
Pentane Insol.	0.08	0.01	0.68	0.52	0.04	0.03	0.30	0.08	0.23
T.A.N.	3.70	4.62	4.97	4.58	4.92	4.20		3.74	3.94
							3.30		
T.B.N.	1.20	1.51	2.93	2.15	1.71	1.73	2.51	1.68	1.16
Anti-freeze	none	neg.	neg.	trace	neg.	neg.	neg.	neg.	neg.
Fuel Dilution	0.4%	0.3%	1.2%	0.7%	0.2%	0.2%	0	0.4%	0.8%
Ag	0	0	0	0.4	0	0	0	0	0
Na	15	19	25	820 11	2	1 100 1	20	37 1	120 55
Zn	950	1,150	1,200	1,400	1,050	1,200	3,400	1,150	2,200
Cu	6	12	12	9	2	· · · 5	5	3 22	17
A1	20 50	16 70	16 70	25 100	10 55	17	24	100	90
Ba Ni	1	0 34 0	70	5	1	110	100	100	1
Cr	1	4	5	14	1	4 11	7 3	7	6
Ca	2,400	1,700	1,700	1,000	1,200	1,600	2,300	2,300	2,000
Fe	50	2	62	120	43	50	72		80
Si	14	12	13	17		11	13	13	12
Sn	10	26	10	30	3 3 3	15	12	13	14
Pb	45	40	45	0 03 80	0.03 52	0.04 55	0.09 55	40	47
P	850	1,000	900	1,400	950	800	950	1,150	1,050
В	0	2	1	5	1	0	0	5	7
Mg	570	540	480	550	340	800	1,150	850	900
V	2	1	3	4	1	4	2	2	5
Мо	2	2	7	11	1	7	3	7	7
Mn	1	5	12	9	73	230	350		280
Cd	0	0	0	1 22	0	0	0	1	0
Ti	0	0	1	1	0	1	0	2	0
	1 qt/4,584	1 qt/ 8,281	1 qt/12,860	1 qt/18,659	1 qt/23,244	1 qt/30,454	1 qt/38,756	1 qt/46,250	1½ qt/54,210
211 11111 / //	1 qt/5,800	1 qt/ 9,462	1 qt/13,460	1 qt/20,159	1 qt/23,739	1 qt/31,559	1 qt/39,556	1½ qt/47,350	1½ qt/55,570
Oil additions/Mi	1 qt/6,718	1 qt/10,409	1 qt/14,660		1 qt/24,800	1 qt/32,707	1 qt/40,163	1½ qt/48,920	1½ qt/56,700
			1 qt/15,900		1 qt/26,317	1 qt/33,609	1 qt/41,007		1 qt/57,490
					1 qt/27,732	1 qt/34,589	1 qt/42,115		
					1 qt/28,800	1 qt/35,250	1's qt/44,349		
						1 qt/35,973	1½ qt/45,153		
	100 a 5 6 0					1 qt/36,839			
						2 qt/37,375	3 8 1 2 2		
						down 1 qt			
						@ OD.			

Drain Interval: 4,000; 8,000

Initial Vehicle Mileage: 1,410 on 8/11/76

Test Oil: BERC

Mileage Date		6,186 10/29/76	11,092 1/10/77		22,124 9/9/77	26,987 4/5/78
Flash, OF	76 eg	405 Bubbled	385	16.0	365	325
Viscosity, SSU @ 100°F		345	353		461	350
Viscosity, SSU @ 210°F		60.86	61.10		67.86	61.58
V.I.		126	124		120	127
Benzene Insol.		<0.01	0.02		0.01	0.52
Pentane Insol.		<0.01	0.03		0.02	1.60
T.A.N.						
0. 1.20		3.80	3.50		3.95	3.58
T.B.N.		1.82	1.21		0.66	1.23
Anti-freeze		neg.	neg.		neg.	neg.
Fuel Dilution		0.4%	0.6%		0.1%	1.7%
Ag		0	0		0	0
Na		28	54		43	16
Zn		860	930		1000	880
Cu		16	9		9	6
A1		21	20		44	30
Ва		80	100		44	110
Ni		1	3		3	3
Cr		3	9		16	12
Ca		2400	3000		2700	2300
Fe		88	105		180	200
Si		26	17		23	20
Sn		20	33		21	13
Pb		40	40		150	98
P		700	700		850 .	700
В		2	1		0	0
Mg		17	17		22	19
V	180	2	3		4	4
Мо		2	8		1	10
Mn		9	/		190	280
Cd		0	0		5	0
Ti		1	3		0	1
					6478777	

Oil additions/Mi

1 qt/5,030

1 pt/13,455

1 qt/14,452

Drain Interval: 4,000; 8,000 Initial Vehicle Mileage: 1,594 on 7/16/76 Test Oil: MORCO

Mileage Date	-	5,610 9/10/76	9,560 11/1/76	13,362 12/17/76	16,992 2/9/77	20,974 3/31/77	29,197 6/28/77	37,465 11/17/77	45,125 3/17/78	48,285 4/24/78
Flash, °F	30 % 101	430	400	415	375	320	425	385	355	410
Viscosity, SSU @	100°F	413	397	417	363	364	496	399	405	406
Viscosity, SSU @	210°F	64.72	64.33	65.55	65.23	62.50	72.39	68.51	00.07	68.97
V.I.		121	0.24	123	133	126	124	126	126	126
Benzene Insol.		0.02	0.01	0.18	0.01	0.02	0.07	0.25	0.02	0.03
Pentane Insol.		0.03	0.03	0.58	0.02	0.03	0.08	0.51	0.03	0.04
T.A.N.		4.48	5.10	4.48	3.33	4.40	4.32	3.21	4.19	4.79
T.B.N.		1.51	2.30	1.66	1.45	2.15	1.82	1.85	2.20	1.88
Anti-freeze										
		neg.	neg.	neg.	neg.	trace	trace		trace	trace
Fuel Dilution		0.4%	0.1%	0.8%	0.8%		0	1.2%	1.2%	0.6%
			137							
Ag		0	0	0	0		0	0	0	0
Na		16	23	25	7	21	20	34	28	29
Zn		1,100	1,200	1,000	1,200	1,350	1,400	4,300	1,100	1,220
Cu		18	23	15	11	7	18	10	5	4
A1		10	23	21	22		41	32	19	14
Ba Ni		60	70	70	70		110	80	75	85
Cr		6	1 5	3	2	3 8	0	4	1 6	1
Ca		2,100	1,900	1,400	1 900	1 500	3,000	1,900	3,400	2,300
Fe		56	62	60	105	54	120	80	92	52
Si		15	14	11	12		13		11	9
Sn		32	28	25	25	22	21	22	22	. 11
Pb		45	52	45	46	62	330	90	56	60
P		550	1,000	700	1,100		1,250		1,400	950
В		1 500	2	2	2	0	0	0	6	4
Mg V		580	500	430	500	560	900	1,250	950	15 5
Мо		5	8	7	10	8 7	6	6	2	5
Mn		10	18	12	9	28	140	270	300	170
Cd		0	1	1	ó	0	0	0	0	0
Ti		2	2	2	4	2	0	0	3	0
		1 qt/3,154	1 qt/6,960	1 qt/10,689	1 qt/14,698	1 qt/18,430	1 qt/22,110	1 qt/30,464	1 qt/38,574	1 qt/46,240
Oil additions/Mi		1 qt/3,531	1 qt/9,088	1 qt/12,235	1 qt/15,515	1 qt/19,328	1 qt/23,380	1 qt/31,342	1 qt/39,566	1 qt/46,880
		1 qt/4,100					1 qt/23,983	1 qt/32,303	1 qt/40,574	1 qt/47,576
							1 qt/24,810	1 qt/33,000	1 qt/41,275	
							1 qt/25,674	1 qt/33,775	1 qt/42,430	
							1 qt/27,041	1 qt/35,428	1 qt/43,478	
								1 qt/36,460	1 qt/44,666	
								1 dr/20,400	1 de/44,000	

Drain Interval: 4,000; 8,000

Initial Vehicle Mileage: 2,173 on 7/27/76

Test Oil: VIRGIN

Mileage Date	6,115 9/20/76	10,115 11/4/76	14,100 12/21/76	18,093 2/14/77	22,040 3/31/77	30,083 6/29/77	38,000 10/4/77	46,256 1/19/78	53,992 4/19/78	54,477 4/24/78
Flash, °F	. 360	390	390	390	370	390	380	350	380	400
Viscosity, SSU @ 100°F	331	380	359	343	367	531	476	483	718	378
Viscosity, SSU @ 210°F	59.57	63.80	61.27	60.33	80.76	72.27	69.16	71.30	85.80	65.64
V.I.	125	125	123	124	119	119	120	124	119	131
Benzene Insol.	< 0.01	< 0.01	<0.01	0.01	0.01	0.01	0.19	0.10	0.14	0.01
Pentane Insol.	< 0.01	< 0.01	< 0.01	0.02	0.01	0.02	0.28	0.17	0.18	0.02
Γ.A.N.	3.36	3.41	4.23	3.46	3.54	4.79	3.75	4.42	5.63	5.17
r.B.N.	0.61	1.63	0.21	0.39	0.39	0.5	0.36	1.23	0.45	0.91
Anti-freeze	neg.	neg.	neg.	trace	trace	neg.	neg.	trace	trace	neg.
Fuel Dilution	0.8%	0.6%	0.4%	0.8%	0.4%	0.4%	0.4%	0.7%	0.8%	0.4%
del blidtion	0.6%	0.6%	0.4%	0.8%	0.4%	1.13	0.4%	0.775	0.0%	
								100		100
Ag	0	0	0.2	0.2	0	0	0	0	0	0
Na	45	27	65	11	10	20	19	24	34	0.7
Zn	800	1,000	770	800	850	1,000	900	1,050	3,000	1,400
Cu	12	13	3	5	2	5	7	5	5	2
A1	20	13	17	19	13	32	34	30	25	8
Ва	85	80	80	90	100	100	120	96	110	95
Ni	3	1	0	5	0	2	1	4	2	1
Cr	5	3	-5	7	8	7	11	10	0	4
Ca	2,000	1,800	1,500	1,650	1,700	2,000	2,400	1,700	2,600	2,200
Fe	78	45	87	140	70	170	150	240	160	4
Si	20	16	13	15	10	18	22	20	19	8
Sn	30	23	25	25	11	27	13	18	8	11
Pb	60	57	61	70	72	320	160	120	85	28
P	270	800	500	750	580	720	750	890	1,220	1,050
В	16	3	11	11	4	5	0	7	4	4
Mg		20	35	52	33	26	13	18	20	16
V	9	5	35	1.	4	4	7	6	8	5
Mo	5	3	7	9	3	10	11	10	10	2
Mn	4 7		the same of the sa	7	3	200	900	750	430	100
mn Cd	,	29	6	1	3	0	0	2	1	0
Cd	1	1	1	1	0	0	0	1	0	0

1 qt/3,667 1 qt/8,100 1 qt/16,115 1 qt/19,710 1 qt/27,938 1 qt/32,132 1 qt/44,310 1 qt/47,888
011 additions/Mi 1 qt/4,831 1 qt/8,700 1 qt/12,600 1 qt/16,115 1 qt/19,710 1 qt/27,938 1 qt/34,038 1 qt/42,920 1 qt/51,775
1 qt/36,649 1 qt/39,777 1 qt/50,265

VEHICLE #A18712
Drain Interval: 8,000
Initial Test Mileage: 1,149 on 8/18/76
Test Oil: VIRCIN

Mileage Date	3,146*	5,120 [*] 12/7/76	7,151* 1/24/76	9,231 4/1/77	11,710 [*] 6/8/77	16,805 9/30/77	24,917 5/11/78
Flash °F	. 395	310	435	400	370	- 47	330
Viscosity, SSU @ 100°F	271	240	291	302	311		329
Viscosity, SSU @ 210°F	56.28	54.12	57.02	58.18	59.00		59.54
V. I.	132	135	128	129	129		126
Benzene Insol.	<0.01	<0.01	0.12	0.01	<0.01		0.05
Pentane Insol.	0.01	0.10	0.24	0.02	0.01		0.07
T.A.N.	2:74	3.28	3.45	3.11	2.94		5.02
T.B.N.	1.39	1.51	0.48	0.66	1.49		0.19
Anti-freeze	trace	neg.	neg.	present	neg.		trace
Fuel Dilution	0.6%	1.0%	1.0%	1.2%	0.4%		1.6%
		770					
	0	0	0.5 0 6	0	4.0		超.
Ag Na	30	42	74	19	1		0 0
Zn	700	800	800	900	920		930
	48	55	53	50	42		22
		7	10	13	8		16
Ba	65	75	100	110	100		90
Ni O		0 31 2	6 0.39	0	2		3
0-	/.	7	10.50	17	6		12
Ca	2000	1600	1600	1600	2500		1800
Fe e 0.9		140	180	210	120		520
Si	0	10	10	13	9		1/.
Sn	20	21	22	23	16		12
Pb	24	38	290	61	41		52
P STORY	300	650	550	700	600		810
В	16	12	10	3	1		1
Mg	13	14	15	13	14		12
	4	4	17 380 3 9 550	6	3		6
Мо	1	0	0	0	0		2
Mn	6	8	11	7	40		530
Cd	2	1	\$\te\13 2 3\71\	2	0		3
Ti	3	2	33.14.197 1 34.9T.V	0	0		1 1 1 2 2 1 3 2 3 3 3 3 3 3 3 3 3 3 3 3

Oil Additions/Mi	1 qt/2,499	1 qt/5,120	1 qt/7,151	1 qt/8,782	1 qt/10,870	1 qt/14,949	2½ qts/
	½ qt/3,146	½ qt/5,120					

^{*}Dipstick samples.

VEHICLE #A18713 Drain Interval: 8,000 Initial Vehicle Mileage: 1,407 on 8/24/76 Test Oil: MORCO

Mileage Date		3,608 [*] 2/7/77
Flash, °F	100	250
Viscosity, SSU @ 100°F		246
Viscosity, SSU @ 210°F		54.11
V.I.		132
Benzene Insol.	λ.	0.01
Pentane Insol.	*	0.03
T.A.N.	1149	2.99
T.B.N.		1.27
Anti-freeze		neg.
Fuel Dilution		2.0%
Ag		0
Na Zn		10 1050
Cu		50
A1		12
Ва		65
Ni Cr		3 10
Ca		1500
Fe		140
Si		11
Sn Pb		25
P D		90 1000
В		1
Mg		420
V		4
Мо	3 4 1	0 0 1
		9
Mn Cd		3

Oil addition/Mi

wrong type of oil used here

^{*}Dipstick sample.

VEHICLE #A18714 Drain Interval: 8,000 Initial Vehicle Mileage: 2,683 on 7/27/76 Test Oil: MORCO

11116161									
Mileage Date	4,831 [*] 9/7/76	7,858 [*] 10/28/76	10,687 12/8/76	17,999 2/28/77	26,789 7/1/77	34,646 10/18/77	42,703 1/24/78		50,560 5/10/7
Flash, °F	370	345	360	58.3	370	350	350	59.24	345
Viscosity, SSU @ 100	0°F 307	330	318		426	434	415		407
Viscosity, SSU @ 210	0°F 58.86	60.01	59.24		66.47	67.15	65.64		65.6
V. I.	130	127	128		123	123	123		125
Benzene Insol.	<0.01	0.03	1.26		0.49	1.14	1.81		1.10
Pentane Insol.	< 0.01	0.84	1.04		0.98		3.32		1.19
T.A.N.	2.93	4.15	5.62		4.00	4.35	5.42		5.92
r.B.N.	1.51	2.78	3.42		1.62	3.22	1.55		0.91
Anti-freeze	neg.	neg.	neg.		neg.	neg.	trace	pr	resent
Fuel Dilution	1.2%	1%	1.6%		0.5%	0.3%	1.3%		1.2%
								1 4	
Ag	0	0	0		0		0		^
Na	10	26	32		30	32	19		0 25
Zn	1,000	1,200	1,100		1,440	1,200	1,100	1997 100	1,200
Cu	14	27	27		27	20	8	0.7	10
A1	2	10	13		11	14	17		13
Ва	30	65	70		100	100	79		80
Ni Z	0	1	3		3	0	2		2
Cr	0	4	9		16	7	10		9
Ca	2,200	1,600	1,500		2,100	2,300	1,900		2,500
Fe	52	100	1,500		78	72	120	har from hed in	70
Si	H 0 3 2 7 2 1	11	13		12	12	13		10
Sn	9		25		20	10	14		9
Pb	50	115	200		1,120	370	160		150
P	880	1,040	980		300	1,000	1,200	A 5 5 5 7	1,000
В	0	2	2		. 0	0	0	1	0
Mg	660	800	500		680	1,100	900		800
V	. 0	2	6		5	6	3		3
Мо	0	0	1		0	0	1		
Mn	0 .	8	11		110	700	700		1
Cd	0	1	1		8	3			600
Ti	0	2	2		0	0	3		1
11	O O	2	2		U	U	1		0
	1 qt/4,056	1 qt/5,951	1 48 2.495		1 qt/21,818		1 qt/39,570	1 at	t/44,
il additions/Mi	½ qt/4,831	½ qt/7,858			1 qt/24,096	2 at/30,468	1 at/40,766		t/47,
	- 40/4,031	- 42,7,030				2 40,30,400	1 40,700		
					1 qt/25,095			2 qt	t/49,1

^{*}Dipstick samples

VEHICLE #A18716 Drain Interval: 10,000

Initial Vehicle Mileage: 2,100 on 7/30/76

Test Oil: VIRGIN

Mileage Date	4,043* 8/24/76	6,155 [*] 9/27/76	8,588 [*] 10/22/76	10,222 11/22/76	20,016 1/31/77		30,033 5/27/77	40,020 10/7/77	50,116 1/10/78	60,613 3/16/78	63,900 4/25/78	
Flash, °F	. 390	400	330	320	325	+ 40	300	360	345	280	310	14.
Viscosity, SSU @ 100°F	266	294	289	270	315		370	351	329	393	340	
Viscosity, SSU @ 210°F	56.24	57.39	56.75	55.92	58.36		62.71	61.52	58.37	67.95	60.93	
v. I.	134	129	128	131	125		125	126	121	133	127	
Benzene Insol.	<0.01	< 001	0.05	< 0.01	0.04		0.01	0.14	0.64	0.66	0.06	
Pentane Insol.	< 0.01	< 0.01	0.08	0.01	0.07		0.02	0.19	0.74	1.44	0.08	
T.A.N.	1.88	3.14	3.20	3.37	3.33		5.70	3.10	4.11	3.97	5.47	
T.B.N.	1.03	0.85	0.85	0.73	0.30		0.39	0.30	0.19	0.12	1.88	
Anti-freeze	trace	neg.	neg.	trace	neg.		neg.	neg.	trace	present	present	
Fuel Dilution	0.8%	0.6%	0.8%	1.2%	0.8%		0.7%	0	1.4%	2.4%	1.7%	
Ag	0	0	0	0	0		0	0	0	0	0	
Na	20	18	40	35	30		32	22	17	25	18	
Zn	930	810	830	800	900		1,100	940	800	940	1,100	
Cu	160	110	100	80	38		23	16	8	9	8	
A1	2	3	11	12	15		15	16	14	15	9	
Ва	75	45	80	85	80		120	98	76	76	90	
Ni	4	1	1	1	4		9	0	3	2	2	
Cr	5	1	7	7	17		16	8	9	11	6	
Ca	2,600	2,000	1,600	1,800	1,800		2,700	1,900	1,800	2,900	1,900	
Fe	45	70	110	115	220		200	120	170	210	100	
Si	8	10	14	14	13		13	11	11	13	9	
Sn	8	4	10	10	17		21	9	12	10	10	
Pb	20	30	52	45	170		240	160	88	140	80	
P	650	530	730	700	700		600	720	700	1,400	950	
В	16	10	13	13	5		2	0	0	5	8	
Mg	10	10	16	16	16		11	15	12	13	15	
V	3	1	3	2	4		7	8	4	2	6	
Mo	0	0	0	0	1		2	0	. 1	1	2	
Mn	0	0	8	6	6		130	300	850	950	380	
Cd	0	0	1	0	2		3	1	1	2	1	
Ti	1	0	2	1	2		1	1	1	1	0	

1 qt/3,821 1 qt/5,502 1 qt/7,142 1 qt/15,730 1 qt/24,250 1 qt/34,350 1 qt/43,894 1 qt/--

^{*}Dipstick samples

Drain Interval: 10,000

Initial Vehicle Mileage: 3,677 on 5/20/76

Test Oil: VIRGIN

Mileage Dat e		5,636 [*] 11/23/76	7,696 [*] 1/12/77		9,631 [*] 2/23/77	11,633* 4/5/77	13,669 5/26/77	15,667 [*] 6/20/77	23,753 12/28/77	28,902 5/15/78
Flash, °F	1613'89	290	340		380	360	405	1 45/43, flag 1 45/ A-	365	335
Viscosity, SSU @	100°F	236	380		282	276	317		340	370
Viscosity, SSU @	210°F	53.47	55.95		56.82	55.69	58.89		62.02	63.25
V.I.		133	128		130	128	127			
Benzene Insol.									130	1.27
		<0.01	0.01	. 0	0.11	0.01	0.01		1.35	1.15
Pentane Insol.		<0.01	0.03		0.16	0.03	0.02		1.42	1.26
T.A.N.		2.46	3.02		2.80	4.10	3.26		4.68	5.47
T.B.N.		1.80	1.30		1.32	1.60	1.60		1.49	0.91
Anti-freeze		trace	neg.		trace	neg.	neg.			
Fuel Dilution		1.7%							neg.	present
rder bilderon			0.8%		0.8%	1.0%	0.4%		1.7%	0.3%
Ag		0	0		0	0	0		100	. 0
Na		27	44		8	10	15		16	21
Zn		900	820		840	930	900		3,500	1,150
Cu		38	34		29	22	8		14	16
Al		6	7		13	12	5		18	16
Ва		70	70		50	100	340 4		95	90
Ni		1	3		6	0	1		18	3
Cr		9	12		12	15	2		25	9
Ca		1,700	1,700		1,800	2,200	2,700		2,200	2,300
Fe Si		60	88		130	110	50		450	160
Sn		9 20	10		13	10	6		17	12
Pb		35	17 30		26	17	13		15	13
P		500	550		46 800	63 270	33		9,000	56
В		6	5		7	1	650	F 8.15 VIO. 0.12	950	1,050
Mg		50	42		57	43	19		1	3
V		3	3		4	4	3		30	12
Mo		1	o		2	0	0		3 45	6
Mn		5	5		14	6	48		48	400
Cd		1	1		2	0	0		0	0
Ti		1	2		2	0	0		2	0
		1 qt/5,000	1 qt/		56.36	62-71		1 qt/14,468	1 qt/14,468	0
(4) 85W W 130°L						379	2014		3.70	
Oil additions/Mi		½ qt/5,636	½ qt/7,696			2 qt/11,145	1 qt/12,153	½ qt/15,667	1 qt/16,340	
									2 qt/18,462	
									1 qt/19,655	
*	8724776									
Dipstick samples					. X0 . G14				1 qt/21,632	
									1 qt/23,569	

VEHICLE #A18718 Drain Interval: 8,000

Initial Test Mileage: 1,685 on 9/16/76 Test Oil: VIRGIN

Mileage Date	3,677 [*] 11/16/76	5,731 [*] 2/8/77	7,900 [*] 4/29/77		9,736 6/15/77		17,849 1/19/78	23,143 5/17/78
Flash ^O F	255	390	370	3	405		325	360
Viscosity, SSU @ 100°F	215	276	301		319		266	284
Viscosity, SSU @ 210°F	52.09	56.02	57.43		59.32		56.21	56.38
V.I.	137	129	127		128		134	128
Benzene Insol.	<0.01	<0.01	0.02		<0.01		0.11	0.10
Pentane Insol.	<0.01	0.01	0.03		0.01		0.13	0.13
T.A.N.	2.64	2.16	3.60		3.17		2.44	2.50
T.B.N.	1.21	0.54	0.83		0.39		1.03	1.23
Anti-freeze		trace	trace					
	neg.				neg.		neg.	trace
Fuel Dilution	1.6%	0.8%	0.8%		0.2%		2 . 2%	1.2%
Ag	0	0	0		0		0	0
Na Zn	20 860	9 850	10 830		15 920		13 860	16 910
Cu	22	24	15		12		11	12
A1	5	8	8		8		15	12
Ва	70	75	80		98	¥"	88	95
Ni same y consumption	1	1	0		1			2
Cr	5	6	1		5		2 7	6
Ca	1700	2000	800		2700		1900	1600
Fe	40	70	64		78		86	57
Si	8	10	7		9		10	8
Sn	16	15	5		15		14	11
Pb	29	52	60		120		100	60
P. Sanda Carres Turker	560	700	600		600		650	700
В	7	5	0		3		0	0
Mg	320	34	25 0		34		18	10
Mo	5	1 0	0		0		4	5
Mn	27	45	47		60		110	160
Cd	1	1	0		0		1	0
Ti	2	4	380 0		0		i	0
							1 qt/11,644	
ort aller a but	1 /2 20/	1½ qt/5,731	1 qt/6,532	-	1 qt/9,236			1 /10 602
Oil Additions/Mi	1 qt/3,304	14 qt/3,/31			1 41/9,236		1 qt/12,374	1 qt/19,602
	½ qt/3,677		$1\frac{1}{2}$ qt/7,900				1 qt/13,639	1 qt/20,538
And the Street all, 4 Me.		5. 1. X6.					1 qt/14,808	1 qt/21,578
Dipstick samples.							1 qt/16,181	1 qt/22,795
							1 qt/17,706	

VEHICLE #A18722 Drain Interval: 8,000 Initial Test Mileage: 1,853 on 7/28/76 Test 0il: MORCO

torical west in millions - 5,477 to \$750.700.

Prints terrison: In. Gov

I communic	4 2 2 3 3	All boards and	III.		والصادي		Andrews and the State of the St	A description
Mileage Date	3,877 [*] 9/22/76	5,915 [*] 11/22/76	7,690 [*] 12/30/76	9,83 2/1/7	8 7	14,177 5/18/77	22,169 8/31/77	26,444 12/29/77
Flash ^O F	330	265	290	29	5	380	400	355
Viscosity, SSU @ 100°F	279	279	254	29	0	306	339	289
Viscosity, SSU @ 210°F	57.01	55.78	54.70	57.0	6	58.72	60.82	57.59
V.I.	132	127	132	12		130	127	130
Benzene Insol.	<0.01	0.09	0.01	0.7		0.01	0.87	0.22
Pentane Insol.	<0.01	0.16	0.85	0.9	5	0.02	1.05	0.26
T.A.N.	3.03	4.30	6.74	5.2	6	5.67	4.23	3.22
T.A.B.	1.94	2.06	1.24	1.3	9	1.60	0.77	2.91
Anti-freeze	neg.	trace	neg.	trac			present	neg.
Fuel Dilution	2.0%	2.0%	1.7%	1.	2%	0.7%	1.3%	1.7%
. dol Britania	10	100			2/6	0.7%	1.5%	1.7%
	10.2	m &_	H					/
Ag	0	0	0.4		0	0	0	0
Na	10	21	. 45	3		21	20	8
Zn	930	1000	1100	110		1300	1100	1050
Cu	21	29	35	3		65	79	23
A1	3	9	13	1		11	13	12
Ва	40	70	60	7.		100	100	88
Ni Ni	mar 1	10 0 1	6	100		8	0	1
Cr	1	6	9	1		9	13	5
Ca	2600	1600	1600	170		2300	1300	1800
Fe	32	40	85	13		54	54	50
Si	6	9	12	1		8	11	8
Sn	10	7.16.	30	2		11	23	17
Pb	24	33	45	5		100	85	55
P	1000	800	850	99		1000	750	900
В	0	2	10.08		2	0	0	0
Mg	700	400	450	45		800	900	750
V	4	3	3			5	9	6
Mo	0	1	1 1 7 2			1	2	1
Mn	2	5	11			59	190	200
Cd	0	1	2		2	2	6	1
Ti	0	1	3 700		2	1	0	1
						1 qt/11,237	1 qt/15,955	1 qt/24,368
Oil Additions/Mi	1 qt/3,270	1 qt/4,536	1 qt/7,590	1 qt/9,	575	1 qt/12,704	1 qt/17,455	1 qt/25,526
	$\frac{1}{2}$ qt/3,877	1 qt/5,915		Ţ.				
	10/30	. 40,5,515				1 qt/13,672	1 qt/19,186	1 qt/26,260
* Dinstick cample							1 qt/21,645	

Dipstick sample.

VEHICLE #A18729 Drain Interval: 8,000

Initial Test Mileage: 1,095 on 8/10/76
Test Oil: VIRGIN

Mileage Date	3,227* 10/19/76	5,382 [*] 12/3/76	7,399 [*] 1/17/76		8,977 2/16/77		16,980 6/29/77	25,599 12/13/77	31,940 4/24/78
Flash ^O F	345	395	345	0	385	7	365	320	345
Viscosity, SSU @ 100°F	. 265	286	290		295		361	360	404
Viscosity, SSU @ 210°F	55.93	57.21	56.99		57.40		61.90	61.44	66.78
V.I.	133	131	128		128		125	124	128
Benzene Insol.	<0.01	<0.01	0.02		0.01		<0.01	0.02	0.88
Pentane Insol.	<0.01	<0.01	0.04		0.03		0.01	0.04	1.26
Γ.A.N.	2.21	2.94	2.98		3.02		3.91	3.34	4.68
Г.В.N.	1.51	1.82	0.73		0.77		1.71	0.24	0.45
Anti-freeze	neg.	neg.	neg.		neg.		neg.	trace	present
Fuel Dilution	1.2%	1.0%	1.2%		1.2%		0.9%	1.2%	0.6%
12 25 /	3.0	30	7.7				7	7.400	30
Ag	0	0	0.2		0.2		0	0	0
Na	40	35	85		15		23	40	23
Zn	940	820	850		820		800	930	1150
Ca	42	37	37		34		26	28	17
A1	7	5	180		10		6	16	11
Ва	100	100	80		100		90	100	90
Ni	0	1	3		6		2	7	2
Cr	4	5	6		7		6	8	6
Ca	1800	1600	1400		1600		2600	1700	2300
Fe	95	110	130		190		100	160	130
Si maninana vaday	10	9	10		11		8	13	9
Sn	-	20	18		26		15	10	13
Pb	52	60	70		80		100	110	70
P	740	500	550		700		550	700	1150
В	17	14	11		12		3	0	4
Mg	ž 15	14	14		16		14	16	17
V	5 330	2	4		4		5	8	312 4 133
Мо	0	3	0		1		0	0	1
Mn	9	10	9		21		180	370	500
Cd	- 25136338	7 A TO A 1 2	59 Vas 1 8		3		3	15/10/1	2131/10/ 0 41/22/1
Ti	1	0	1		2		0	0	EL 354 4 0 -3.99
0il Additions/Mi	1 qt/2,172 ½ qt/3,272	1 qt/5,144 ½ qt/5,382	1 qt/6,54 1 qt/7,39				1 qt/14,135	1 qt/22,276	1 qt/29,211

*Dipstick samples.

VEHICLE #A18731 Drain Interval: 8,000

Initial Vehicle Mileage: 1,509 on 11/1/76

Test Oil: MORCO

Mileage Date	3,829 [*] 12/10/76	5,551* 1/10/77	7,760 [*] 2/10/77		9,643 3/18/77		17,806 6/24/77	25,535 9/8/77		33,805 12/16/77	41,755 3/27/78		45,091 4/28/78
Flash, °F	320	335	340	. 0	310	6	410	370	306	340	325	77	375
Viscosity, SSU @ 100°F	276	312	329		381		409	390		409	382		356
Viscosity, SSU @ 210°F	56.32	58.89	60.41		61.20		65.20	64.05		65.30	63.25		62.17
V.I.	130	129	128		118		123	124		124	124		124
Benzene Insol.	< 0.01	<0.01	0.03		0.25		0.61	0.38		0.88	1.50		0.52
Pentane Insol.	0.01	0.01	0.07		1.40		0.71	0.52		1.59	1.72		0.72
T.A.N.	3.20	3.91	3.28		6.13		3.94	3.74		4.93	4.60		3.98
T.B.N.	3.36	2.30	1.27		1.87		1.54	2.63		2.09	1.29		2.46
		A COLUMN											
Anti-freeze	neg.	neg.	neg.		neg.		trace	neg.		trace	trace		neg.
Fuel Dilution	0.5%	0.7%	0.8%		0.4%		0	0.3%		0.4%	1.6%	1	0.8%
Ag	0	0	0		0		0	0		0	0		0
Na	25	70	15		9		20	1		30	19		20
Zn	1,000	1,100	1,200		1,300		1,200	2,500		3,900	1,000		1,200
Cu	28	33	32		37		23	15		8	7		6
A1	5	6	11		12		7	11		16	12		7
Ba	60	70	75		110		95	110		90	66		90
Ni	0	2	. 2		5		0	. 2		5	2		1
Cr	6	11	13		13		8	13		8	16		6
Ca	1,700	1,400	1,600		1,700		2,300	1,800		1,500	2,600		1,700
Fe	39	47	70		90		47	44		50	78		30
Si	8	8	11		12		9	40 03 11		11	9		6
Sn	18	23	23		27		12	12		11	11		10
Pb	28	36	42		65		180	120		110	79		50
7, 25,b 2 210 2	800	780	1,100		1,200		1,000	1,000		1,200	1,370		920
A 22 B S 100 B	102 2	1	2		1		0	0		0	0		0
Mg	450	400	440		630		750	1,950		1,100	800		750
V	3 3	2	3		0		4	392 4		1150	3		5
Mo	i	0	0		1		0			0	0		1
	70\13\\20	5	7		16		140	270		360	420		270
Cd		2 21	2		3		0	5		0	1		0
Ti	3,223 3	2	2		0		. 0	16,989 0		0	3		0

Oil additions/Mi

[uff]@[ales] wf[extended on 01 qt/3,441 1 qt/5,432 1 qt/7,734 ½ qt/3,829 1 qt/5,551 ½ qt/7,760

1 qt/12,866 1 qt/21,495 1 qt/29,300 1 qt/37,785 1 qt/15,475 1 qt/23,366 1 qt/31,420 1 qt/39,580

^{*}Dipstick Sample

VEHICLE #A18744 Drain Interval: 10,000 Initial Test Mileage: 1,004 on 7/26/76 Test Oil: MORCO

Mileage Date	3,138 [*] 9/2/76	5,035 [*] 10/12/76	8,155 [*] 12/30/76	10,174 [*] 2/7/77	11,056 2/18/77	21,367 8/24/77	28,296 12/27/77
Flash °F	420	390	370	365	385	375	365
Viscosity, SSU @ 100°F	345	386	371	423	422	443	446
Viscosity, SSU @ 210°F	61.10	63.88	62.33	65.23	66.89	68.84	68.71
V.I.	126	125	124	121	125	126	125
Benzene Insol.	<0.01	<0.01	<0.01	0.65	0.42	0.43	0.39
Pentane Insol.	<0.01	0.01	0.51	0.74	0.76	0.62	0.63
T.A.N.	3.43	4.47	5.70	4.11	4.45	3.60	3.96
	0.91	1.63	0.70	0.66	1.77	1.07	1.94
T.B.N.							
Anti-freeze	none	neg.	neg.	trace	trace	neg.	neg.
Fuel Dilution	0.6%	0.5%	2.0%	0.0%	0.2%	0.7%	0.8%
Ag	0	0	0.5	0	0.3		3 · · · · ·
Na /	16	50	100	45	25	18	19
Zn	960	1200	1300	1200	1200	2350	3300
Cu	14	26	28	31	35	20	9
A1	4	10	17	18	15	14	19
Ba	20	60	70	70	70	110	89
Ni	0	5	6	2	6	0	1
Cr	1	6	8	9	8	11	4
Ca	2000	1900	1600	1800	1600	1600	2000
Fe	60	60	120	200	190	86	100
Si	9	13	20	23	17	13	13
Sn Sn	10	45	55	50	45	31	15
Pb	64	120	160	180	180	140	90
P	800	470	900	1000	1100	800	1150
B acceptant seed to de	0	5	6	5	7	0	0
Mg	500	550	500	450	480	1000	900
V	0	4	5	3	4	8	4
Mo	0	0	1	1	ī	2	1
Mn	0	8	11	12	11	200	400
Cd	0	1	1	1	1	4	0
Ti	0	2	2	2	2	0	1
11	U	2		2	27,501.1.2	•	
						1 qt/12,731	1 qt/22,630
Oil Additions/Mi	1 qt/2,359	1 qt/4,378	2 qt/6,508	1 qt/9,368	1 qt/10,541	2 qt/14,528	2 qt/24,030
	½ qt/3,138	½ qt/5,035	½ qt/8,155	½ qt/10,174		2 qt/17,279	2 qt/26,151
	i e e i					2 qt/20,439	2 qt/27,268

*Dipstick samples.

VEHICLE #A18745 Drain Interval: 10,000 Initial Vehicle Mileage: 2,255 on 7/26/76 Test Oil: VIRGIN

Mileage Date	4,374 [*] 8/27/76	6,327 [*] 10/6/76	8,363 [*] 11/3/76	9,940 12/10/76	12,020 [*] 1/22/77	19,974 7/22/77	30,464 2/9/78		33,998 5/8/78
Flash, °F	415	1.0 %	390	375	- 4	1 690	365	100	370
Viscosity, SSU @ 100°F	303		351	366			358		360
Viscosity, SSU @ 210°F	58.67		61.56	62.12			61.52		63.0
V.I.	130	1.79730	126	124			125		128
Benzene Insol.	< 0.01	1927	<0.01	< 0.01			0.05		0.02
Pentane Insol.	< 0.01		< 0.01	<0.01			0.07		0.03
T.A.N.	2.47		3.28	3.84			3.39		4.81
T.B.N.	0.97		0.036	1.43					1.23
Anti-freeze	none								
		2.00	neg.	neg.			neg.		trace
Fuel Dilution	0.6%		0.7%	1.4%			0.7%		0.8
								2300	
Ag	0		0	0			0	137	0
Na Zn	30 850		55 830	90 850			75 9 50		43
Cu	18	3.0	23	35			15		1,100
Al	4		13	16			27		10
Ba	50		70	80			100		80
Ni	0		1	3			2		1
Cr	0		3	9			10		7
Ca	2,200		1,600	1,500			2,700		3,000
Fe	48		95	150			280		65
Si	7		13	14			18		10
Sn Pb	60		31 135	37 130			19		9
P	680		500	500			120 900		43 850
B 39.4	14		19	15			13		12
Mg	12		16	17			16		11
V	0		4	4			3		4
Мо	0		3 0	1			1		0
Mn	0		9	15			750		230
Cd	0		0	0			0		0
Ti	3 778 0		9 14 2 T	2			1		0

1 qt/9,129

½ qt/12,020

1½ qt/5,100 1 qt/6,800 0il additions/Mi ½ qt/4,374 ½ qt/6,327 1 qt/8,363

*Dipstick Samples

VEHICLE #A20363 Drain Interval: 4,000 Initial Test Mileage: 2,457: Hrs 127

Test Oil: VIRGIN

Mileage/Hrs Date	3,719 [*] /269 1/4/77	6,908/467 5/12/77	11,372/753 11/3/77	14,061/ 12/15/77		17,799/ 5/5/78
Flash °F	295	390	365	360	330	305
Viscosity, SSU @ 100°F '	232	321	308	270	381	309
Viscosity, SSU @ 210°F	52.73	58.72	57.50	55.25	64.25	59.0
V.I.	132	125	124	128	127	130
Benzene Insol.	1.92	1.44	2.42	1.41	2.09	0.39
Pentane Insol.	2.32	2.12	4.60	1.89	3.58	0.57
T.A.N.	4.45	10.70	7.18	5.76	5.75	3.74
T.B.N.	0.79	1.10	0.48	0.36	0.78	1.23
Anti-freeze	neg.	neg.	neg.	neg.	neg.	neg.
Fuel Dilution	1.6%	1.2%	1.2%	1.7%	2.4%	2.0%
Ag	0.2	62.	18	8 12 -	0	0
Na	43	20	17	33	57	13
Zn	720	900	900	820	1150	1000
Cu	24	27	33	26	32	7
A1	11	16	21	18	42	4
Ba	50	75	100	75	98	76
	6	16	18	16		3
	22	43	30	24	27	6
Cr Ca	2000	2500	2800	2100	2200	3200
			380	270		52
Fe		300	16	17	440 21	6
Si	10 16	21	18	15	32	10
Sn	10		3050	18,500	32	4400
Pb control in the state of the	11,500	19,000			17,000	
P	480	540	750	700	1000	870
В	,	2	0	•	3	6
Mg	700 30 . 172	18	23	24	21	18
V	0	2	2	5	2	4
Мо	15	29	37	30	10	6
Mn	45	34	38	180	110	48
Cd	0	0	0	0	2	0
Ti	5	1	0	0	2	1

2 qts/--

Oil Additions/Mi/Hrs	1 qt//152	1 qt/5,722/366	1 qt/8,348/545
	1 qt//220	2 qt/6,207/403	2 qt/9,293/598
Lattial Vebriels Wilseger		1 qt/6,635/453	2 qt/10,451/672

*Speedometer broken

Drain Interval: 4,000
Initial Vehicle Mileage: 1,218; Hrs 127 on 9/20/76
Test Oil: VIRGIN

Mileage/Hrs Date	4,888/271 12/7/76		8,938/616 3/21/77	13,338/914 8/3/77	17,309/1151 11/29/77	18,741/1282 12/11/77	23,362/1607 1/30/78	26,504/1845 3/7/78	29,479/ 5/9/78
Flash, °F	. 330	- 8	360	370	385	365	350	355	365
Viscosity, SSU @ 100	O°F 245		339	337	266	253	386	356	355
Viscosity, SSU @ 210	0°F 53.39		58.45	59.04	55.86	54.34	64.40	62.06	61.24
V.I.	130		118	121	132	130	126	127	125
Benzene Insol.	1.98		2.83	1.64	0.89	0.60	2.57	1.54	1.40
Pentane Insol.	4.90		4.43	2.02	1.11	0.95	3.38	2.01	1.64
T.A.N.	5.76		8.12	5.85	4.21	3.80	6.58	4.52	4.72
T.B.N.	1.78		0.61	1.60	1.19	0.97	1.10	2.00	0.84
Anti-freeze	neg.		neg.					trace	
Fuel Dilution	0.8%		0.8%	neg.	neg.	neg.	trace		trace
rder brideron	0.3%		0.0%	1.4%	1.2%	2.0%	2.0%	1.6%	1.6%
Ag Na Zn Cu Al Ba Ni Cr Ca Fe Si Sn Pb P B Mg V Mo	0.2 45 850 25 13 60 20 2,100 860 15 21 30,000 700 7 50		0 13 960 30 16 90 22 25 3,700 2,400 18 30 22,000 850 3 24 0 50	0 37 1,000 32 21 91 13 35 2,300 300 17 21 22,500 700 11 16 5	0 23 940 18 19 85 10 20 2,000 300 16 12 15,000 750 0 16 8	0 13 840 10 9 75 4 8 1,800 120 8 13 10,500 600 0 11 3	13 5 8	0 24 1,000 17 10 68 3 11 2,800 150 10 14 12,000 875 10 15 2 3	0 26 1,150 31 16 80 11 14 2,300 230 14 18 11,500 870 7 14 5 8
Mn Cd	62 2		18 1	13	64	34	38 1	0	0
Ti	3		2	0	0	0	2	1	0
	1 qt/3,130/1	93 1	qt/5,599	1 qt/ 9,788/695	2 qt/14,350/	2 qt/	1 qt/19,299/1320	2 qt/23,712	2 qt/27,177/1882
Oil additions	1 qt/3,852/2	30 1	qt/	1 qt/ 9,970/711	1 qt/15,622/ 986	1 qt/17,809/1177	2 qt/19,659/1351	2 qt/24,177	2 qt/28,309/1954
	1 qt/4,882/2			2 qt/ 1 qt/11,633/821 1 qt/12,119/ · 2 qt/12,598/881		2 qt/18,086/1198 1 qt/18,505/1231	2 qt/20,432/1407 2 qt/20,877/1435 2 qt/21,393/1468 2 qt/22,758/1548	2 qt/24,775 2 qt/25,289	

VEHICLE #A20365 Drain Interval: 4,000 Initial Test Mileage: 1,458; Hrs 66 Test Oil: MORCO

Mileage/Hrs Date	78. 90	6,081/337 1/27/77	10,429/626 6/9/77	14,717/ 11/29/77	20,130/218 3/14/78	21,234/320 5/16/78	
Flash °F		350	330	370	360	335	
iscosity, SSU @ 100°	F .	312	311	305	437	298	
iscosity, SSU @ 210°		57.19	57.89	57.84	66.15	58.08	
.I.		122	125	127	120	130	
enzene Insol.		5.32	4.00	3.15	4.56	1.07	
entane Insol.		8.12	4.14	4.68	6.21	1.68	
.A.N.		8.09	6.68	6.37	7.19	5.20	
.B.N.	100	1.33	1.66	1.49	3.10	2.26	
nti-freeze		neg.	neg.	neg.	neg.	neg.	
		1.0%	0.4%				
uel Dilution		1.0%	0.4/3	0.8%	1.2%	1.8%	
Ag		0	0	0	0	0	
Na		25	27	27	33	48	
Zn		1120 31	1100	1100	1550 24	1200 14	
Cu A1		37	25	17 26	25	18	
Ba	V 80 13	70	67	70	68	75	
Ni		30	13	14	8	3	
Cr		43	40	30	33	17	
Ca		1900	1900	2000	2600	2100	
Fe		1200	470	700	410	300	
Si		65	19	33	22	16	
Sn		53	12	17	18	12	
Pb		30,000	18,000 800	16,000	20,500	8000	
P		1200	0	980	1200	980	
В		500	620	1000	1000	750	
Mg V		3	0	6	2	4	
Mo		90	20	31	17	8	
Mn		60	10	64	90	39	
Cd		2	0	0	1	0	
Ti		3	0 2	0	1	0	
		1 qt/2,794/138	1 qt/6,985/391	1 qt/11,476/673	3 qt/15,852/823		
		2 qt/3,534/174	1 qt/8,251/484	1 qt/12,281/715	1 qt/16,507/ 22*		
l Additions/Mi/Hrs		1 qt/4,450/223	1 qt/9,282/563	1 qt/12,541/737	2 qt/17,309/ 62	1 qt/20,421/	
		1 qt/5,212/282	1 qt/9,791/606	1 qt/13,169/750	2 qt/17,589/ 79	2 qt/20,980/	
				1 qt/13,648/788	2 qt/18,100/118		
New hour meter at 82	23.		*	1 qt/14,021/812	1 qt/18,493/137		
					2 qt/18,993/164		
					1 qt/19,686/202		
			7 1997 6 (1999)		2 qt/19,863/208		
					- 40,17,005,200		

VEHICLE #A20366 Drain Interval: 4,000 Initial Test Mileage: 1,256; Hrs 66 on 11/12/76 Test Oil: VIRGIN

Mileage/Hrs Date	5,308/333 11/28/77	7,330/433 1/6/78	10,902/672 4/5/78
Flash ^O F	350	360	340
Viscosity, SSU @ 100°F	230	321	402
Viscosity, SSU @ 210°F	52.58	60.33	64.95
V.I.	132	130	124
Benzene Insol.	1.76	1.61	4.07
Pentane Insol.	2.46	1.94	5.57
T.A.N.	5.51	4.42	6.88
T.B.N.	0.30	1.94	0.65
Anti-freeze			
	neg.	neg.	trace
Fuel Dilution	1.7%	1.7%	2.4%
Ag	0	0	0
Na Na	28	14	36
Zn	880	1150	1200
Cu	32	9	19
A1	28	9	15
Ba	. 80	84	98
Ni Cr	52 44	7 14	6 35
Ca	1800	2100	2700
Fe	1200	180	280
Si	33	. 9	17
Sn	24	11	10
Pb	1700	10,500	25,000
P 9 9 9 9	700	850	730
В	5	4	3
Mg	79 6	26	18 2
V Mo	110	14	14
Mn	34	12	. 15
Cd		12 0 12 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0
Ti	0.	2	3
	3 4 4 - 1 5 - 4 1 5		
1 1 2 2 2 2	1 qt/2,472/173		1 qt/8,481/5
Oil Additions/Mi/Hrs	1 qt/3,994/254	1 qt/6,323/	1 qt/9,411/5
	1 qt/4,446/290	1 qt/6,915/	1 qt/9,609/6
있다. 이 제계하는 기계하는 기계하는 기계하는 기계하는 기계하는 기계하는 기계하는 기	1 qt/4,759/309		

VEHICLE #A20367 Drain Interval: 4,000 Initial Test Mileage: 1,315; Hrs 54 Test Oil: MORCO

Mileage/Hrs Date	5,678/261* 2/7/77	9,263/4 6/16/	13,622/581 10/26/77		16,102/689 12/21/77
Flash °F	350	390	355	-	
Viscosity, SSU @ 100°F	262	276	261		
Viscosity, SSU @ 210°F	53.62	55.26	54.13		
V.I.	124	126	127		
Benzene Insol.	3.71	2.47	1.72		
Pentane Insol.	5.49	3.65	3.56		
T.A.N.	7.17	5.70	6.31		
T.B.N.	1.66	1.10	1.31		
Anti-freeze	neg.	neg.	neg.		
Fuel Dilution	1.6%	0.4%	0.8%		
Ag	0	0	0		
Na	11	12	13		
Zn	1050	1000	1100	1	
Cu	26	10	14		
A1	13	11	25		
Ва	50	80	80		
Ni	14	5	20		
Cr	23	20	32		
Ca	1600	1300	2300		
Fe	1000	150	550		
Si	17	9	16		
Sn	35	1	15		
РЬ	28,000	12,000	21,000		
P	1000	600	800		
В	4	0	0		
Mg	450	470	21		
V	2	0	1		
Mo	26	24	30		
Mn	37	17	17		
Cd	2	0	0		
Tí	3	0	0		

Oil Additions/Mi/Hrs	1 qt/21,100/103	1 qt/7,298/321	1 qt/10,114/439	1 qt/15,995/685
	1 qt/27,773/129	1 qt/7,762/355	1 qt/12,501/530	
* Replaced Gasket (oil pan)	2 qts/4,059/187	1 qt/8,467/383	1 qt/12,899/548	

VEHICLE #A20368
Drain Interval: 4,000
Initial Test Mileage: 1,568; Hr 1 on 8/15/76
Test Oil: MORCO

Mileage/Hrs Date	5,620/194 1/31/77	10,420/434 8/9/77	14,240/618 11/21/77
Flash ^O F	355	365	340
Viscosity, SSU @ 100°F	283	290	208
Viscosity, SSU @ 210°F	55.68	56.82	50.8
V.I.	126	127	133
Benzene Insol.	3.08	3.64	3.03
Pentane Insol.	4.71	4.21	5.11
T.A.N.	6.36	9.23	6.87
T.B.N.	1.45	0.48	0.46
Anti-freeze	neg.	neg.	neg.
Fuel Dilution	0.4%	0.8%	2.8%
Ag	0	0	0
Na	340	1	17
Zn	1100	1100	1000
Cu	25	18	16
A1	15	24	21
Ba	60	75	68
Ni	13	15	18
Cr	18	40	22
Ca	1800	1600	1800
Fe	550	520	700
Si	15	15	20
Sn	30	16	13
Pb	20,000	17,500	16,000
F F P	1100	750	840
В	4	0	0
Mg	450	700	850
V	2	2	6
Мо	28	36	40
Mn	30	21	42
Cd	1	0	0
Ti	2	2	0
Oil Additions/Mi/Hrs	1 qt/1,568/	1 qt/6,849/262	1 qt/12,640/54
OII Additions/FII/IIIs	1 qt/3,759/106	1 qt/7,600/320	1 qt/13,661/53
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\			- qc/15,001/55
	1 qt/5,379/181	1 qt/8,100/440	

VEHICLE #A20369

Drain Interval: 4,000

Initial Vehicle Mileage: 1,364; Hrs 45

Test Oil: MORCO

Mileage/Hrs Date	5,329/265 12/29/76	9,368/504 3/22/77	13,310/696 5/25/77	17,369/855 8/3/77	21,363/1,042 11/15/77	25,325/1,260 1/5/78	29,267/1,473 3/9/78	31,676/ 4/25/78
lash, °F	355	350	385	390	365	355	370	340
iscosity, SSU @ 100°F	266	310	300	299	272	309	317	292
iscosity, SSU @ 210°F	54.83	56.14	56.30	56.90	56.02	58.72	58.41	57.96
·.I.	127	118	122	125	131	129	125	131
enzene Insol.	2.93	4.29	3.43	3.59	3.78	4.36	3.81	1.29
entane Insol.	4.46	6.12	3.33	5.03	5.12	4.83	4.00	1.77
.A.N.	8.25	8.73	9.49	7.05	7.09	7.53	5.73	7.56
.B.N.	0.88							
		1.16	1.05	0.59	1.19	0.84	1.16	0.97
nti-freeze	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.
uel Dilution	1.4%	0.9%	0.9%	0.8%	1.2%	0.6%	2.0%	1.8%
Ag	0.2	0	0	0	. 0	0	0	0
Na /	52	3	15	20	14	0	22	19
Zn	1,200	1,200	1,200	1,200	1,100	1,150	1,100	1,200
Cu	25	25	14	18	14	14	16	10
A1	12	11	7	18	16	10	16	8
Ba	60	75	72	28	68	78	88	75
Ni	13	13	13	12	1	6	7	2
Cr	23	24	21	37	16	17	23	9
Ca	1,000	1,800	2,100	1,600	2,500	1,800	2,300	2,200
Fe	1,200	1,100	290	36	400	280	310	120
Si	17	14	10	14	13	12	18	8
Sn	33	25	14	21	15	11	14	10
Pb	22,500	20,000	18,600	17,000	18,000	16,500	13,500	7,000
P	940	1,100	800	950	900	450	1,000	900
В	3	2	0	0	0	0	0	0
Mg	420	510	560	800	1,000	850	800	750
V	2	0	2	6	1,000	4	3	4
Мо	32	27	24	. 28	25	16	19	7
Mn	61	18	13	19	52	100	56	50
Cd	1	1	1.3	3	0	1	0	0
Ti	1		1	0	0	1.1	U	0

1 qt/3,739/169 2 qt/7,054/375 1 qt/15,522/784 1 qt/18,847/ 934 1 qt/22,728/1114 1 qt/26,101/1309 1 qt/29,829/1501
0il additions/Mi 1 qt/5,047/246 1 qt/8,383/490 1 qt/12,427/668 1 qt/16,010/803 1 qt/19,326/ 955 2 qt/23,341/1185 1 qt/26,542/1327 1 qt/30,193/1519

1 qt/20,459/1003 1 qt/23,970/1181 2 qt/27,000/1354 1 qt/31,093/1561

1 qt/21,071/1032 1 qt/24,150/1192 1 qt/27,199/1363 1 qt/31,453/1585

1 qt/27,410/1380

1 qt/27,806/1395

1 qt/28,340/1428

1 qt/28,658/1443

1 qt/28,899/1458

VEHICLE #A20370 Drain Interval: 4,000

Initial Test Mileage: 1,297; Hrs 59

Test Oil: MORCO

Mileage/Hrs Date	5,022/237 1/21/77	9,250/476 5/23/77	13,281/657 8/23/77	17,162/846 12/6/77
Flash F	360	390	370	355
Viscosity, SSU @ 100°F	287	317	277	274
Viscosity, SSU @ 210°F	56.21	58.11	55.95	55.88
V.I.		123	129	129
Benzene Insol.		3.95	2.55	3.28
Pastone Issal	3 00	4.23	3.46	4.44
5.0				
From the Front Co.	0	6.88	7.82	6.60
T.B.N.	1.63	1.00	0.60	0.60
Anti-freeze	neg.	neg.	neg.	neg.
Fuel Dilution	1.2%	0.0%	0.8%	2.4%
Ag	0	0	0	0
Na	35	20	17	21
7 n	1150	1100	1100	1100
Cu	25	11	11	12
A1	15	12	14	14
Ba	65	1	65	72
Ni Ni	. 9	8	10	7
Cr Cr	21	3	34	19
Cn	1900	1900	1500	1700
Fe	650	310	260	290
Si		11	12	14
Cn.	30	14	24	12
Pb	22,000	15,400	13,750	17,000
P	1100	800	600	840
В	4	0	0	0
Mg	500	600	950	1050
V 20.14	3	0	5	5
Mo	24	23	25	25
Mn	22	11	21	82
Cd	1	0	3	0
Ti	3	0	0	0

Oil Additions/Mi/Hrs	1 qt/2,707/126	1 qt/7,064/350	1 qt/11,632/583	1 qt/15,000/738
	1 qt/3,773/	1 qt/7,860/404	1 qt/12,398/623	1 qt/16,099/783
		1 qt/8,478/444		1 qt/16,560/812

VEHICLE #A20371 Drain Interval: 4,000 Initial Test Mileage: 1,756;Hrs 66 Test Oil: VIRGIN

Mileage/Hrs Date	5,768/281 2/2/77	9,535/456 5/3/77	13,393/717 9/29/77	17,150/910 12/7/77	21,139/1,088 1/18/78	24,956/ 3/6/78	27,207/ 4/25/78
Flash ^O F	330	355	345	365	315	350	355
Viscosity, SSU @ 100°F	229	266	236	238	299	324	304
Viscosity, SSU @ 210°F	52.69	54.77	52.63	53.80	58.98	60.76	58.4
V.I.	133	128	129	134	133	131	129
Benzene Insol.	3.12	1.56	2.07	4.06	3.69	2.91	1.23
Pentane Insol.	4.85	2.15	2.87	4.31	4.86	5.23	1.91
r.A.N.	6.00	7.82	8.18	7.00	5.49	6.23	6.03
I.B.N.	0.24	0.33	0.06	0.18	0.52	2.20	0.64
Anti-freeze	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Fuel Dilution	2.0%	1.2%	2.8%	2.10%	2.9%	2.5%	1.2%
/	2.0%	2.2%	2.0%	-110%	2.7%	2.3%	1.2%
Ag Na Zn Cu A1 Ba Ni Cr Ca Fe Si Sn Pb P B Mg V Mo Mn Cd Ti	0 17 770 30 14 55 14 26 1800 1200 17 32 30,000 680 7 43 1 33 40	0 3 600 17 22 38 13 29 1000 270 10 3 26,000 420 2 14 0 38 7	0 1 800 26 31 69 34 70 1400 1150 22 19 22,500 680 0 17 8 110 26 5	0 40 850 50 25 80 44 50 1800 1800 38 18 23,000 700 0 15 9 100 110	0 22 1100 17 15 78 10 25 1900 440 16 16 18,000 900 4 17 3 19 81	0 27 1000 14 12 86 5 28 2700 400 13 15 19,000 1000 4 16 3 8 63 0	0 24 1100 111 10 80 3 14 3000 220 15 12 9000 860 6 30 4 5 48
il Additions/Mi	1 qt/4,158/202 1 qt/3,083/159		1 qt/12,062	1 qt/16,562/ 1 qt/16,883/	2 qt/19,918/	1 qt/22,924/ 1 qt/24,056/	2 qt/26,940/

INSPECTION OF ENGINES FROM THE IOWA RE-RENNED OIL FLEET TEST

APPENDIX B

SWRI REPORT: INSPECTION OF ENGINES FROM THE
IOWA RE-REFINED OIL FLEET TEST

Approved by

Vice President ...

APPENDIX R

SWRI REPORT: INSPECTION OF ENGINES FROM THE TOWA RE-REPINED OIL PLEET TEST SOUTHWEST RESEARCH INSTITUTE

Post Office Drawer 28510, 6220 Culebra Road

San Antonio, Texas 78284

INSPECTION OF ENGINES FROM THE IOWA RE-REFINED OIL FLEET TEST

FINAL REPORT MED REPORT No. 107

by

Edwin A. Frame

prepared by

Mobile Energy Division
Southwest Research Institute
San Antonio, Texas

under contract to

Iowa State University Ames, Iowa

May 1978

Approved by:

R.D. Quillian,

Vice President

Mobile Energy Division

SOUTHWEST RESEARCH INSTITUTE
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I. Introduction

For the past two years Iowa State University (ISU) has conducted an oil fleet test using Iowa Department of Transportation (IDOT) vehicles (Ref 1). The test was designed to provide a direct comparison of the performance of two re-refined oils and a virgin based oil. Southwest Research Institute (SwRI) assisted in selecting 12 engines to be disassembled for deposit ratings and wear measurements. The wear measurements were made by IDOT personnel. This report includes the deposit ratings made by SwRI, and a technical interpretation of the overall fleet test results.

IA. Test Lubricants (Ref-1)

Two re-refined engine oils and one virgin based engine oil were included in the fleet test. All three oils were SAE viscosity grade 10W/30 and had SE-CC API service classifications. The two re-refined oils were produced from different re-refining methods. The Motor Oils Refining Company (MORCO) oil was re-refined using conventional acid/clay treatment, while The Bartlesville Energy Research Center (BERC) oil was re-refined using a BERC developed solvent extraction technique. The virgin oil was purchased by IDOT on a bid basis and was described as being composed of mid-continent high V.I. solvent extracted neutral basestocks. Table 1 contains inspection properties of the three test oils.

IB. <u>Test Vehicles (Ref-1)</u>

The IDOT test fleet consisted of twelve 1976 AMC Matadors, twelve 1976 Dodge pickups (1/2 ton, light duty emissions), ten 1975 Chevrolet Malibus and ten 1976 Ford F-750 trucks (heavy duty emissions). The twelve vehicles which were selected for engine tear down and inspection included representative Matadors, Dodges and Ford F-750's listed in Table 2. These vehicles operated on their factory fill engine oil for their first 1000 to 3000 miles at which time they were switched to a test oil.

II. Deposit Ratings

Deposit ratings for the twelve engines shown in Table 2 were made by SwRI during the week of 15 May 1978. The engines had been removed from the vehicles and disassembled by IDOT personnel. The engines were rated for sludge and varnish deposits according to the methodology of standard CRC Engine Rating Manuals No. 12 & No. 9 (Ref-2 & 3). The sludge and varnish ratings were made following the guidelines of the ASTM Sequence VC procedure (Ref-4), which specifies the locations on various engine parts where ratings are to be made. In addition, each engine was visually examined for valve lifter rust, unusual wear, and other significant conditions which included:

LUBRICANT ANALYSES

PROPERTY	MORCO	TEST OILS BERC	VIRGIN
Vis., 38°C, SSu	316	375	318
Vis., 99°C, SSu	61.6	67.8	63.7
This report includes the IV	136	137	141
TAN HOLDES STEERE LEGICIES ST.	2.2	2.4	1.6
TBN	5.4	3.9	3.3
API°	29.2	29.2	29.9
Flash Point, °C gas beend might	207	218 gas ber	207
Sulfated Ash, w%	1.00	1.30	0.71
Elemental mo			
Ba, ppm	29	25 01016 01	T 35 od 3 om
Mg, ppm	650	9	Bart Tesvill
Ca, ppm	1950	2600	1900
Zn, ppm	980	830	820
p, ppm sirredorg norrangent a	800	650	650
S, %	0.58	0.50	0.46
Na, ppm	5	chicles 4 Ref-	16
Basestock Description	Re-refined	Re-refined	Mid-Cont.Hi VI
Process Description	Acid/clay	BERC solven	t solvent extracted
Formulated Quality Level	SE-CC	SE-CC	SE-CC

Maradors, Dodges and Ford F-750's disted in Table 2. These

TABLE 2
TEST FLEET VEHICLES INSPECTED

Vehicle Type	Engine Size (in. 3)	Fuel Type	Oil Drain Interval	BERC Vehicles	MORCO Vehicles	Virgin Oil Vehicles
1976 Matador Wagons	360	Unleaded	8,000	A17680 A17686	A17685 A17687	A17688 A17683
1976 Dodge Pickups	225	Unleaded	8,000		A18731	A18729
	225	Unleaded	10,000	- 1 N	A18710	A18716
1976 Ford 750-Trucks	361	Leåded	4,000		A20369	A20371

- o intake and exhaust valve condition including recession and burning
- o Connecting rod bearing condition
- o piston scuffing
- o valve lifter wear patterns
- o piston rings condition

The complete rating worksheets including a summary cover page for each of the twelve engines are in the Appendix. The ratings of all engines inspected are summarized in Table 3. In the following section the results of the deposit ratings will be discussed and interpreted.

III. Interpretation of Results

In attempting to interpret the results of this oil fleet test several key variables must be considered when comparing oil performance through deposit ratings. The following variables all impact on the deposition results:

- o lubricant base stocks (origin and refining treatment)
- o lubricant additive package composition
- o fuel composition variations (e.g. leaded or unleaded, presence of manganese)
- o type of vehicle operation/service (e.g. highway or city, amount of idling time)
 - o oil drain interval
 - o oil consumption rate
 - o accumulated mileage

In comparing like vehicles from the Iowa fleet test, type of operation will be considered a constant as will fuel composition. As well as can be established, like vehicles were used in about the same type of service. While variations in fuel composition occurred during the test (e.g. manganese started appearing in the used oil of vehicles using unleaded gasoline about one year after test initiation), it is assumed that all vehicles experienced about the same change in fuel composition. The other variables were either well controlled or known.

One additional point needs clarification before the results are interpreted. Because each of the three lubricants contained a different additive package in addition to differences in base

TABLE 3 DEPOSIT RATINGS

(10=clean)

						SLUDG	SE .					VARNIS	Н			DEPOSIT	
VEH ID	MILES	OIL	* COVERS	INT. MANIF.	OIL PAN	VALVE DECK	PUSH ROD CHAMBER	TIM1NG COVER	AVG	PIST. SKIRT	ROCKER COVERS	LIFTER BODIES	CYL WALLS	OIL PAN	AVG	INT. VALVE S	1
A17686	27,000	В	9.7	9.7	9.7	10.0	10.0	9.7	9.8	8.2	8.3	7.4	9.0	9.5	8.5	6.8	
A17680	45,888	В	9.6	9.9	9.7	9.7	9.7	9.7	9.7	5.8	8.8	7.2	8.2	8.7	7.7	7.0	
A17687	48,285	M	9.7	10.0	9.7	10.0	10.0	10.0	9.9	9.8	9.0	7.9	9.5	9.0	9.0	7.4	
A17685	60,174	M	9.7	9.9	9.7	10.0	10.0	10.0	9.9	9.5	8.5	7.6	8.8	9.0	8.7	4.1	
A17683	49,503	V	9.9	9.8	9.8	10.0	10.0	9.7	9.9	7.9	8.7	7.3	8.8	9.0	8.3	4.9	
A17688	54,477	V	9.6	9.7	9.8	10.0	9.9	10.0	9.8	6.0	6.2	5.0	6.1	8.6	6.4	6.6	
A20369	31,576	M	9.4	9.6	9.2	9.4	9.7	9.7	9.5	9.0	5.3	8.1	9.5	7.4	7.9	6.9	
A20371	27,207	v	9.3	9.4	9.5	6.2	9.7	9.5	8.9	6.4	3.6	7.3	7.0	6.2	6.1	7.1	
A18731	45,091	М	9.7	NA	9.7	10.0	NA	9.8	9.8	7.4	8.7	9.0	9.5	7.5	8.4	6.2	H
A18729	31,950	V	9.2	NA	9.2	9.7	NA	9.1	9.3	6.1	5.0	8.9		5.5	6.4	7.4	
A18710	25,617	М	9.5	NA	9.7	9.7	NA	9.3	9.6	9.0	7.0	9.5	9.1	7.6	8.4	7.7	
A18716	63,910	V	8.3	NA	9.1	9.7	NA NA	8.6	8.9	5.7	4.8	7.6	5.1	5.1	5.7	6.5	

NA = Not Applicable

^{*} Oil Codes

B = BERC oil

M = MORCO oil

V = Virgin based oil

stock composition, it is nearly impossible to differentiate between basestock effects and additive package effects when reviewing the deposition results. The fact that all three oils were of SE-CC quality helps minimize the differences in additive package effectiveness; however, small subtle differences in additive package effectiveness can mask the effects of basestock differences. This point does not reduce the importance of the Iowa oil fleet test, but is made to help insure that only valid conclusions are drawn from the data.

IIIA. AMC Matadors

Three of the AMC Matador wagons provided the best overall performance comparison of the different lubricants. Table 4 shows key ratings for these three engines. All three engines had about the same mileage and all three switched from the 4000 mile oil drain interval to an 8000 mile oil drain interval

TABLE 4
AMC ENGINES
WITH SIMILAR MILEAGE
(10=clean)

	1 Jub			VAR	NISH			INT	VALV
VEH			OIL CONSUMP.	PIST.	CYL	AVG	AVG ENG	DEP	OSITS
ID	OIL	MILES	QT/1000mi	SKIRTS	WALLS	ENG	SLUDGE	AVG	WORST
A17680	В	45,888	0.19	5.8	8.2	7.7	9.7	7.0	5.5
A17687	M	48,285	0.70	9.8	9.5	9.0	9.9	7.4	5.5
A17683	V	49,503	0.55	7.9	8.8	8.3	9.9	4.9	1.5

at about the same mileage. The MORCO oil gave superior results in controlling engine varnish and had a 9.8 average piston skirt varnish rating which is exceptional. The pistons from the BERC oil had significantly more varnish than the other two oils; however, the BERC oil had excellent oil consumption performance. Engine sludge results for all three engines were nearly the same. The virgin oil had rather dirty intake valves, including one which had a 1.5 deposit rating. The MORCO oil had significantly higher oil consumption than the other two oils. This resulted in the engine being exposed to more "fresh" oil containing undepleted additives which may be a contributing factor to the excellent varnish ratings observed with the MORCO oil.

The other three AMC vehicles did not have mileages which were directly comparable; however, some generalizations can be made based on the data shown in Table 5.

with the virgin oil engine being slightly more severe. Overall, engine A20369 which used MORCO oil was in better condition than A20371 which used virgin oil.

IIIC. Dodge 1/2 Ton Pickups

Two of the Dodge pickups inspected had operated using 8000 mile oil drain intervals (ODI), while the other two had 10,000 mile ODI. Table 7 shows key deposit ratings for the vehicles having 8000 mile ODI. While the mileages of the two vehicles were quite different, some interesting results were observed. A18731 (MORCO) had accumulated >13,000 more miles than A18729, but had

TABLE 7 DODGE PICKUPS

8000 mi ODI

			men lin tesu	ol edi	VARN	ISH		SLUDGE	INT	VALV
VEH			OIL CONSUMP	PIST.	ROC.	CYL	AVG	AVG	DEP	OSITS
<u>ID</u>	OIL	MILES	QT/1000mi	SKIRT	COVER	WALLS	ENG	ENG	AVG	WORST
A18731		45,091	0.23			9.5				
A18729	V	31,950	0.21	6.1	5.0	6.7	6.4	9.3	7.4	7.0

much less varnish and slightly less sludge deposition. Oil consumption rates were about the same; however, A19731 (MORCO) had heavier intake valve deposits and slightly more piston scuffing. In comparing these two vehicles, the overall performance of the MORCO oil was far superior based on its better ratings at higher mileage.

The two Dodge pickups with 10,000 mile ODI did not provide a good comparison of MORCO and virgin oil performance. The vehicle using virgin oil had accumulated >38,000 more miles than the MORCO lubricated vehicle. As would be expected under these conditions the virgin oil engine had much more sludge and varnish deposition. The only unusual results from these two vehicles was the MORCO oil engine, despite its lower mileage, had twice the oil consumption rate as the virgin oil engine. Also, the MORCO oil engine had several compression rings with very light corrosion.

IV. Summary/Conclusions/Recommendations

Several significant points can be made in summarizing the results of the Iowa re-refined oil fleet test.

1. No major engine failures occurred during the test program. The engines which were inspected were generally in acceptable condition. Based on engine condition, the two rerefined oils and the virgin based oil were judged to have performed satisfactorily. In some cases the re-refined oils had better deposition performance than the virgin based oil.

TABLE 5 AMC ENGINES

(10=clean)

				BASK CR	VARN	ISH		INT	VALV
VEH			OIL CONSUMP.		CYL	CYL	AVG	DEP	OSITS
ID	OIL	MILES	QT/1000mi	SKIRTS	BODS	WALLS	ENG	AVG	WORST
11 7404	ven e	0.7.000	ens tor again	181 0120	m ada	0 0	- 100	plim	0008.
A1 7686	В	27,000	0.13	8.2	4.4	9.0	7.9	6.8	5.0
A17685	M	60,174	0.77	9.5	7.6	8.8	8.7	4.1	1.5
A17688	V	54,477	0.39	6.0	5.0	6.1	6.4	6.6	5.0

egy A20371 whitehitship vis

No significant differences in sludge ratings existed for any of the six AMC engines inspected. Once again the MORCO oil gave excellent varnish protection in all areas; however, this engine had heavy intake valve deposits and as with other engine using MORCO oil, high oil consumption was observed. The engine using BERC oil once again had the lowest oil consumption rate. Despite higher mileage, the engine from A17688 (virgin oil) had less intake valve deposits than the other AMC engine which used virgin oil (A17683). Reasons for this annomoly are unknown.

IIIB. Ford F-750's

The two Ford F-750's which were inspected provided a good comparison between the MORCO and virgin oil. Key areas of major differences are shown in Table 6.

TABLE 6 Ford F-750 ENGINES

(361 cu. in.)

				The second second	VARNISH	The second secon	SLUI		INT	VALV
VEH			OIL CONSUMP							OSITS
ID	OIL	MILES	QT/1000mi	SKIRT	COVER	ENG	DECK	ENG	AVG	WORST
A20369	M	31,576	1.06	9.0	5.3	7.9	9.4	9.5	6.9	5.5
A20371	V	27,207	0.46	6.4	3.6	6.1	6.2	8.9	7.1	6.0

Despite having slightly higher mileage, the engine operated on MORCO oil (A20369) had significantly less overall sludge and varnish deposits than the engine operated on virgin oil (A20371). However, A20369 had twice as high an oil consumption rate as A20371. As observed in the AMC engines, the MORCO oil generally provided very good deposition control, but had a significantly higher oil consumption rate. Despite being fueled with leaded gasoline, neither engine had appreciable rust on the valve lifters. A very light "lead paint" type deposit was found throughout both engines. A20371 (Virgin oil) had very light corrosion on seven of the compression rings, while A20369 (MORCO) had very light corrosion on only two compression rings. Both engines had some dished valve lifters

- 2. The observed differences in performance between the re-refined oils and virgin oil could be either basestock effects and/or additive package effects.
- 3. The MORCO oil had a tendency towards superior deposit control, but generally had higher oil consumption rates in the AMC and Ford engines which were inspected. It is recommended that the MORCO oil composition be further investigated using a technique such as gas chromatographic boiling point distribution to determine if the higher oil consumption rate can be correlated to base oil volatility. Some of the vehicles inspected had rather brittle valve guide seals which could be contributing to oil consumption. The engine manufacturers (AMC, Ford, Dodge) should be contacted to determine if they have experienced any unusual valve guide seal problems.
- 4. Two AMC engines had at least one very heavily deposited intake valve which could cause engine problems in the future.
- 5. The wear measurements made by IDOT were reviewed. For the most part, the measurements tend to indicate very little wear took place. Some notable exceptions were:
 - o A20369 (F-750, MORCO) had three ring gaps which were excessive.
 - o Two AMC's (MORCO) each had from 1 to 3 rings with rather high gap.
 - o Two Dodges (Virgin oil) and one Dodge (MORCO) had some rather high exhaust valve guide wear.

The ring gap wear observed for the AMC's and the Ford F-750 using MORCO oil may have contributed to their higher oil consumption rate.

6. Overall, the results were very positive with respect to the field performance of the two lubricants made from re-refined components.

V. Acknowledgements

The author wishes to acknowledge the help and co-operation of Iowa State University and The Iowa Department of Transportation in arranging the engine inspection details. Also special recognition is made of Mr. E.R. Lyons who provided the expert deposit ratings.

VI. References research education and bluod lie aignly bus allo

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- 2. CRC Sludge Rating Manual No. 12, Sept, 1977.
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APPENDI X

INDIVIDUAL DETAILED ENGINE DEPOSIT RATING FORMS

Ratori d.k. Lyons

0

- CRC Variabh Bacing Mailfrag Jand Fright 1971.

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A17686

Engine Type:

AMC,,360 CID

Miles:

27,000

Oil Type:

BERC Rerefined

Oil Drain Interval:

4000 mi for 11,000 miles 8000 mi for balance

Sludge Deposit*

Varnish Deposits*

Rocker Arm Covers 9.7 Intake Manifold 9.7	Rocker Arm Covers	8.2
Oil Pan 9.7 Valve Deck Area 10.0		7.4
Push Rod Chamber 10.0	the state of the s	9.5
Timing Gear Cover $\frac{9.7}{9.8}$	AVG. VARNISH	3.5

Additional Ratings*

Stuck Valve Lifters Stuck Compression Rings	0	Piston Varnish, Max. 9.4 Piston Varnish, Min. 6.4	•
Stuck Compression kings Stuck Oil Rings	0	Intake Valve Deposits, Max. 8.0 Intake Valve Deposits, Min. 5.0)
		Intake Valve Deposits, Avg. 6.8	

Clogging

Push Rods, No. 0 Oil Ring, % 0 Oil Screen, %

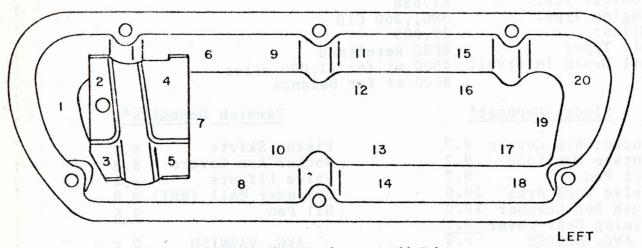
Observations, Comments

Date: 5-78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH					1					SI	TE	gni	T.B.	A.	Inc	ioi	TE	66/	1		TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	, W	8				, A	i M	8 1	21	17.7	sV	EV E	1 2	í q			ġ		Q f	ŔŔ	ssion	Compri	Stuck
1/4A	0	x	x	ald	x	x	x	x	х	x	x	x	x	x	x	х	x	x	х	x	18	90	.22
1/2A x	x	5.	. 13	x	0.16	31		ECH		W.L	SV	50	E T	n I a I						7	2	10	.05
3/4A			* 0	701				T. Co.															
Α																							
AB																						paing	ro.
В						-4																	
ВС																٠.,					0 .0	10 y 20 000	THEN T
С													*								.0 . 5	.reen,	e fio
D																							
E																							
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		GRAND TOTAL													-	20	100	.27					

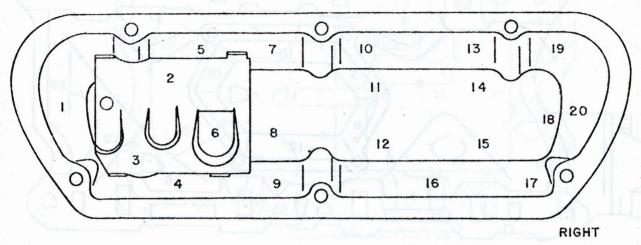
Inspector ERL

Sludge Merit Rating 9.7

Date _______

Date: 5-78 Rater: E.R. Lyons * 10-Clean

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

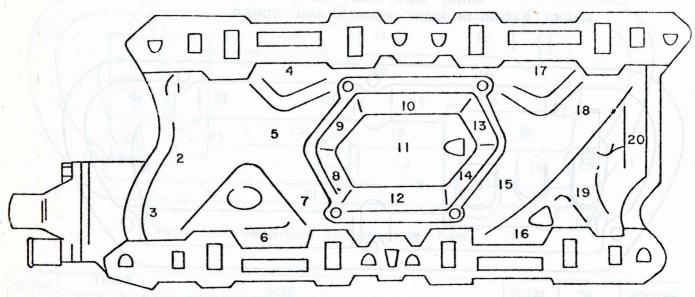
DEPTH		air	EV	so			15	olo		S	TE					ST					TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN							H		h											-			
1/44		х	х	x	x		x	х	x	х	x	х	x	x	x	х	x	x	x	x	18	90	.22
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Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.7}{9.7}$ Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2}$

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

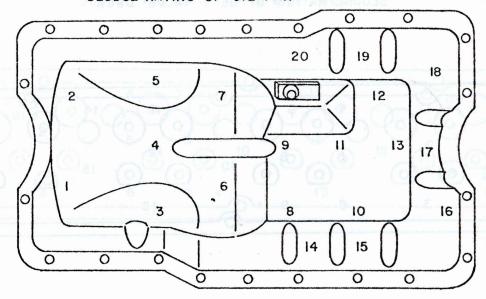


DEPTH										S	TE						-				TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	=	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN								7								Ŧ					18 61	81418	1 346
1/44	x	x	х	х	x	x	х	х	X	x	х	x	X	x	x	х	X	х	x	x	20	100	.25
1/2A	9		T																		t +×t	x + x + x -	APV
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E		-						-	H										F				
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Date 5-78

Sludge Merit Rating 9.7

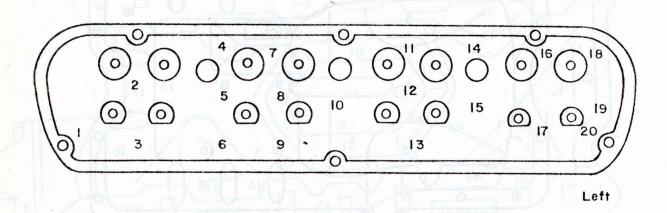
Rating Work Sheet No. 3 SLUDGE RATING OF OIL PAN



DEPTH										S	TE										TOTAL	%	VOLUX
SCALE	i	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
KABID	38.5		T I		H0	Ţ		- 18		Πį				Πß		T					14. 14.	ETSIT	
1/4A	x	х	x	х	х	x	x	x	х	x	x	x	х	x	x	х	x	x	x	x	TX X	XXXX	FREE
1/2A																							APA
3/4A																							ASAT
Α			7 1	: P.																			TAPAC.
AB										1											DETER		A
В					-																		BA
ВС			-11																				8-
С			-1																				28
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E					1																		0.
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н	Market St.					1						7					1						
1														- 17					1				
														730	G	RAN	חו	TOT	TAI		111		

Inspector_ Date _____5-78 Sludge Merit Rating -

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



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x x
1-1-1
1 1

Sludge Merit Rating 10.0

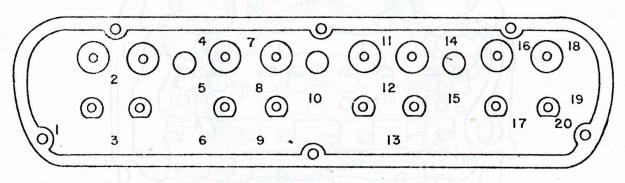
ERL

5-78

Inspector-

Date-

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



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R	u	1)	ı

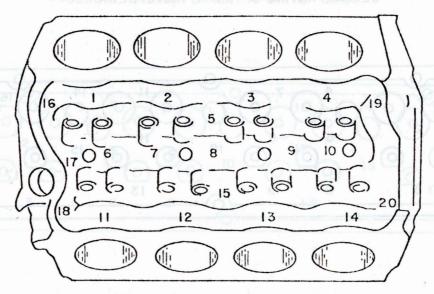
AP JAN	M. L.	SITE			VOLUA
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1-1-4-1-4-					H
				GRAND TOTAL	

Inspector — ERL

Date — 5-78

Sludge Merit Rating $\frac{10.0}{2}$ Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2}$

Rating Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER

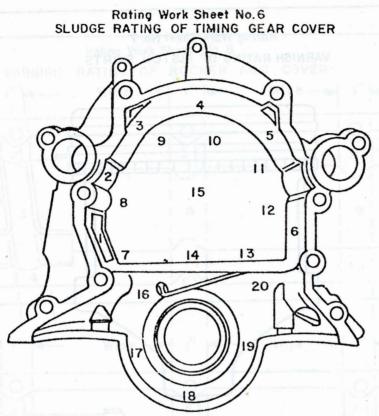


Note: Sites on Vertical Surfaces at Mid-Point

DEPTH			9	_	MT	or l		1010		SI	TE		elvitet			871	e-				TOTAL	% COVERED	VOLUME FACTOR
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS		
CLEAH	x	x	x	x	x	х	x	X	х	х	х	x	x	x	х	x	х	x	х	x	HATX	1x-1x-1x	CLEAN
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1/2A													1										1.4211
3/4A																				++			ABLE
A															-	-							<i>f</i> t
AB																				Ш			L BA
В				-																-			<u>1_a_</u>
ВС																						ļļ	28
С					-										-								2
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E														-									1 3
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н									1												1-1-1-1		1
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Inspector	ERL
Doto	5-78

Sludge Merit Rating 10.0

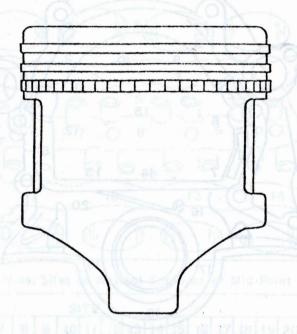


Note: Sites on Vertical Surfaces at Mid-Point

DEPTH	MA	LAB	di	6		and a	ġ3	VA		SI	TE			1	H	18			0	h	TOTAL		VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS		FACTO
CLEAN	1	Ma	10			1	Ø.	1	1	•	- 8				ŧ,					1 %	+ Mosmis	E IDUE	14
1/4A	x	х	x	x	x	x	x	x	x	x	x	х	x	х	x	x	х	х	х	х	20	100	.25
1/2A										-												Lam	e GH
3/4A					- 14													or principal	Total Control				14
A		2147	7.6								7.0			1	10 %	120							
AB		Caye	10	10			3 , 5				, 9				6				P	h h f	Adeal	ATIMA	COM
В		O RATE	10								. 0				9.	8			3			2.5 Ton	40
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E			7									a ·			8.	63			JA	101		1,011	
F			8							sim	Ris	iln.			T.F	0.7		2 ,,	8.				
G			77																			7.0.	
Н		Į-,																			TOTAL	190	
	8	18	OTF	lin	191		18:	ndï	QVA		011	TA S	Н	1 101	ų A.S								
Ir	spe	ecto	r_I	ERL								nspi	ègie	in-r	G	RAN	4D	TOT	TAL	nh.	ستوساه	10	
D	ate		5-	- 78																luda	e Merit F	atina	9.7

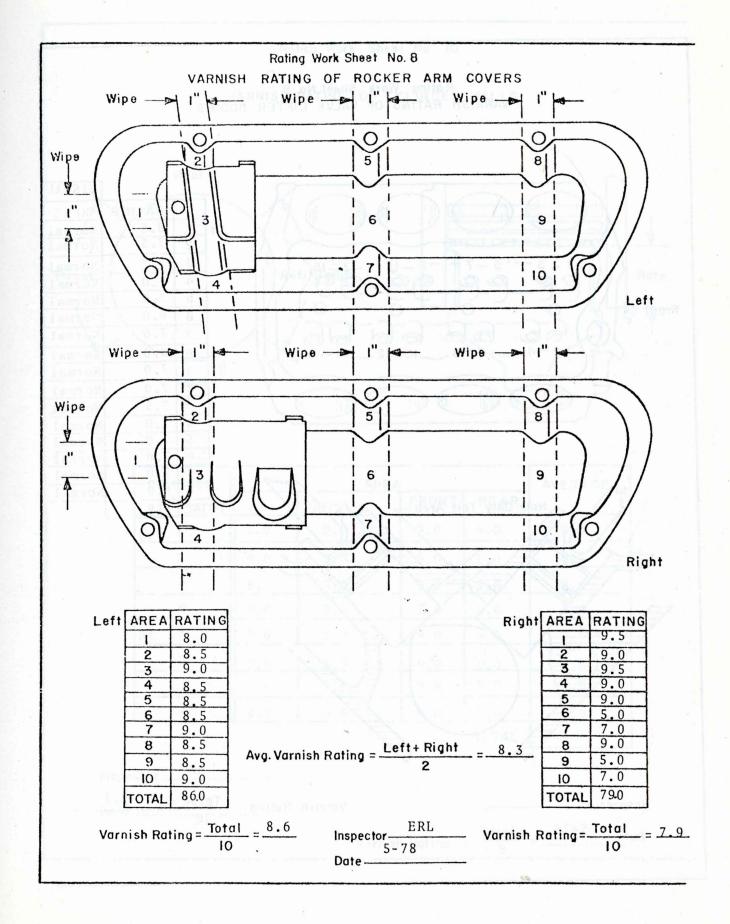
Rating Work Sheet No. 7

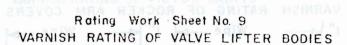
VARNISH RATING OF PISTON SKIRTS

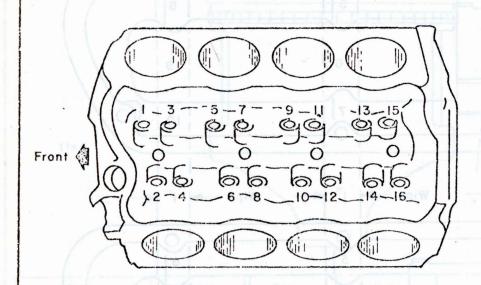


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
Lt Scuff Camsd	-Lt	9.4	8.8	9.1	Normal Normal
Normal	2 x x	9.2	8.8	9.0	Normal
Normal	* 3	8.0	6.9	7.5	Norma1
Normal	4	7.4	6.9	7.2	Normal
Normal	Rt 1	8.9	9.0	9.0	Normal Normal
Normal	2	8.9	9.0	9.0	Norma1
Normal .	3	6.4	7.6	7.0	Normal .
Normal	4	7.6	8.5	8.1	Normal
	TOTAL	65.8	65.5		
	AVERAGE	8.2	8.2		

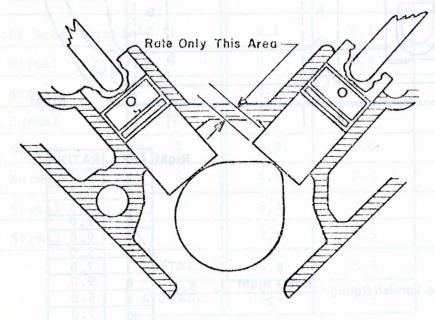
Inspector		VARNISH RATING = AvgThrust + Avg Antithrust	8.2
Date	ATOT O	VARISH RATING - 2 193 yelse	Inspi







11	-11		VISUAL
	JIC.	RATING	WEAR
Lt	1	8.5	Norma1
	2	7.5	Normal
	3	7.2	Norma1
-	4	7.0	Norma1
	5	7.0	Normal
	6	8.0	Normal
	7	7.6	Normal
84	8	8.0	Norma1
Rt	1	7.0	Normal
	. 2	7.0	Normal
	3	7.5	Normal
	4	7.0	Normal
	5	7.0	Norma1
	6	7.0	Normal
	7	7.0	Normal
	8	8.0	Norma1
TO	TAI	1183	



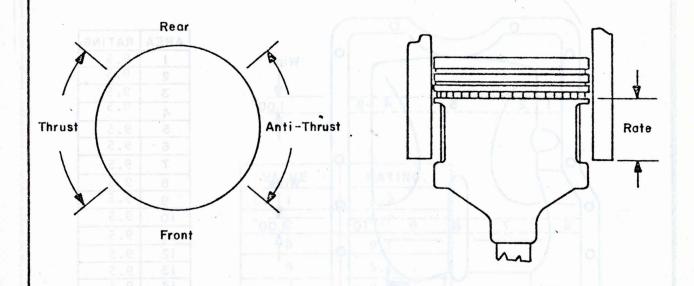
Inspector

Date ______5-78

Varnish Raing =
$$\frac{\text{Total}}{16}$$
 = $\frac{7.4}{}$

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



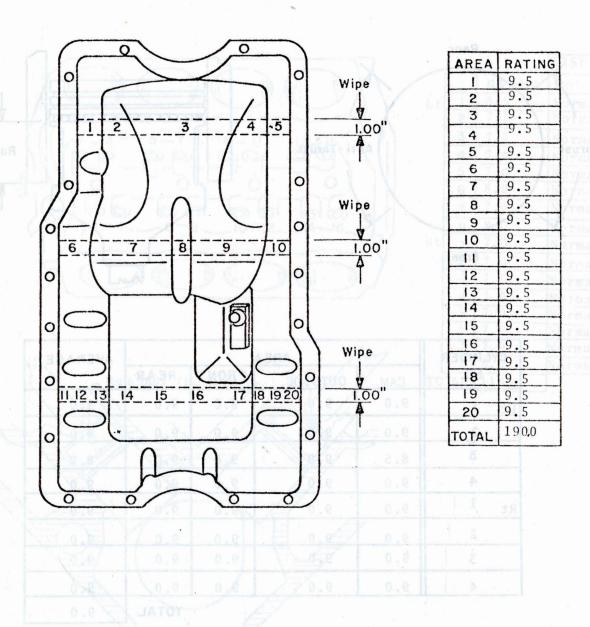
CYLINDER	- 94	AREA									
NO.	CAM	OUTSIDE	FRONT	REAR	AVERAGE						
Lt I	9.0	9.0	9.0	9.0	9.0						
2	9.0	9.0	9.0	9.0	9,0						
Ohs 3 vact	8.5	9.0	9.0	9.0	8.9						
4	9.0	9.0	9.0	9.0	9.0						
Rt 1	9.0	9.0	9.0	9.0	9.0						
2	9.0	9.0	9.0	9.0	9.0						
3	9.0	9.0	9.0	9.0	9.0						
4	9.0	9.0	9.0	9.0	9.0						
DELO				TOTAL	9.0						

Inspector ERL

Date _____5-78

Varnish Rating = $\frac{\text{Total}}{8} = \frac{9.0}{100}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



Inspector ERL

Date -

5-78

Varnish Rating = Total = 9.5

Rating Work Sheet No. 12

INTAKE VALVE DEPOSITS

VALVE	RATING	
Lt I	6.5	1
2	6.0	
3 (9.0	nash, bax 6
4	5.0	DESTRUMENTS MARK S
Rt 1	8.0	lve Terrosits, Min. S
2	8.0	De Deposito, Avg. 7
3	8.0	
4	5.0	
TOTAL	545	

Visual Observation of Seat, recession, or burning: Recess-Normal Burn-None

Avg. Rating= $\frac{\text{total}}{8} = \frac{6.8}{}$

Inspector _	ERL	inda - C
Date	5-78	

. 50

K		
. 0		
	8.0 8.0 0 5.0 0 5.0 0 5.0	2 8.0 eqy 8.0 ya 9.0 TOTAL coss-Normal Burn-None

ENGINE INSPECTION SUMMARY

A17680 PADOR TEEL BOOKITAR BOOKIE Vehicle I.D.:

AMC, 360 CID Engine Type:

Miles:

45,888 BERC Rerefined Oil Type:

4000 mi for 15,000 miles 8000 mi for balance Oil Drain Interval:

Sludge Deposit*

Varnish Deposits*

Rocker Arm Covers	9.6	Piston Skirts	5.8
Intake Manifold	9.9	Rocker Arm Covers	8.8
Oil Pan	9.7	Valve Lifters	7.2
Valve Deck Area	9.7	Cylinder Wall (BRT)	
Push Rod Chamber	9.7	Oil Pan	
Timing Gear Cover	$\frac{9.7}{9.7}$	AVG. VARNISH	7 7

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max. 6.9
Stuck Compression Rings	0	Piston Varnish, Min. 5.4
Stuck Oil Rings	0	Intake Valve Deposits, Max. 8.0
		Intake Valve Deposits, Min. 5.5
		Intake Valve Deposits, Avg. 7.0

Clogging

Push Rods, No. Oil Ring, % 0 Oil Screen, %

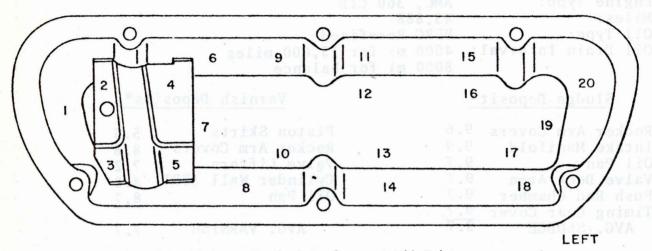
Observations, Comments

Date: 5 - 78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH									-	SI	TE										TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	0	8	χı	M	. 3		10.0	90	91	rie	V	6 1	sj.	ıĺ					0		ings	g-rto.	Stack
1/4A	3	х	n.	x	e 8	d į	(0.0	x	x	r I a	x	ox	8.1.	х				х			7	35	.09
1/2Ax	x		x	70	x	x	x	au	.33	x		x	x	3 1	x	x	x		х	х	13	65	. 32
3/4A																							
Α					1												,						
AB								- 2															
В																					0 al	Rods,	Push
ВС												¥									0 .	E 52 8 11 11	011
С																							
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			•					-							G	RAN	ND.	TOT	TAL		20	100	.41

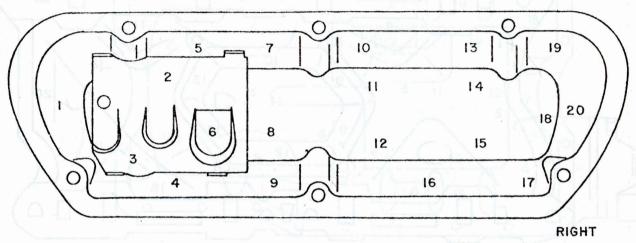
Inspector ERL

Studge Merit Rating 9.6

Date ______

Rater: 5-78

Rating Work Sheet No. la SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

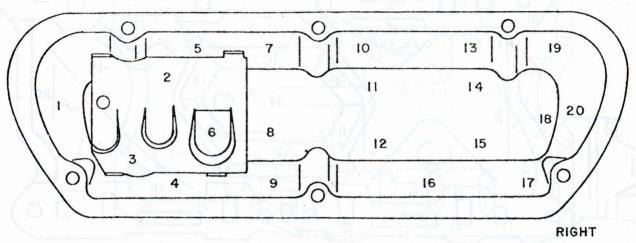
DEPTH				II	JAJ					SI	TE					17					TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN			4														X					xix	LEASI
1/4A	x			x	x	x	x	70-1	х	x	x	x	x			x	х		х		13	65	.16
1/2A		x	x					x						x	x			x			6	30	.15
3/4A																				х	1	5	.04
Α				2		1																	- A
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В						-4																	
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Inspector ___ERL 5-78

Date -

Sludge Merit Rating -Avg. Sludge Merit Rating= $\frac{\text{Left} + \text{Right}}{2}$

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

DEPTH					JA T			Į.		SI	TE										TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN													M				7					HXIXI	LEABLE
1/4A	x		N.	x	x	x	x	20	х	x	х	x	x			x	x		х		13	65	.16
1/2A		x	х					x						x	x			x			6	30	.15
3/4A																				х	1	5	.04
Α																							-H-A-
AB																							BA
В						-4																iri i	# 9-
вс																							n va
С																							11-7-
D																						H + H	11-10-
E																							1 3
F																							-
G				П																		think	# 0
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									1								- 4						He I
	Τ		18.1					JA	rgr		SAF	IĐ.			G	RAN	חו	TOT	ΔΙ		20	100	. 35

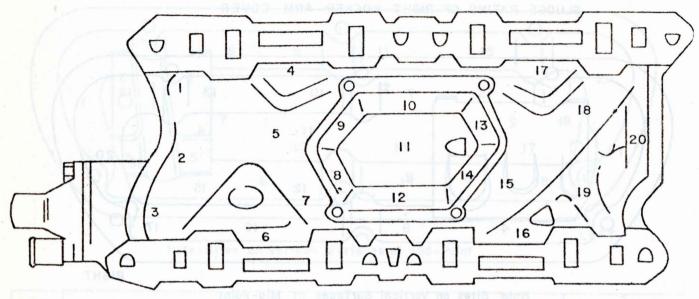
Inspector ERL

Sludge Merit Rating 9.6

Date ______

Avg. Sludge Merit Rating= Left+Right = 9.6

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

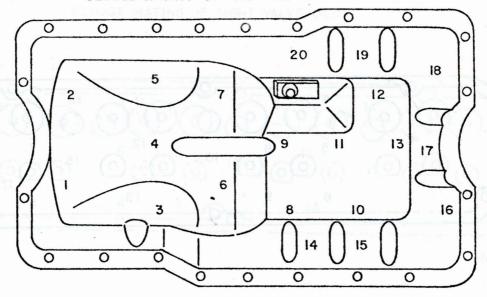


DEPTH	3				at.					SI	TE	12		H			131	18		20	TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	x	x	x	х	x	x	х	х	x	x	x	x	x	x							14	70	ligan
1/4A					¥.	X	Z			4					x	х	x	x	x	х	6	30	.08
1/2A																							451
3/4A																							AAAE
A																							Δ
AB																							BA
В																							8
ВС																	12						1 28
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Sludge Merit Rating 9.9

Date 5-78

Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN



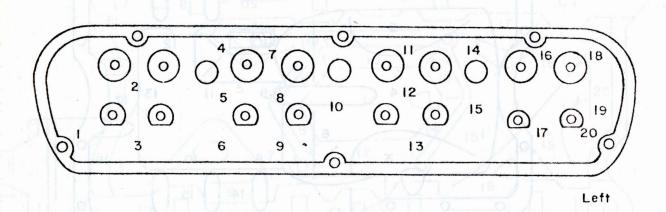
DEPTH	100									S	ITE										TOTAL	%	VOLUX
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN																		+	82	84			
1/4A	x	х	x	х	x	x	x	x	x	x	x	x	x	x	x	x	х	x	x	x	20	100	. 2.5
1/2A																							PAS 1
3/4A																							26.7.1
Α																							
AB		alter of											- Kree										
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ВС		0									12									-	+		
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	1	1.											4 =		G	RAN	ND.	TO	TAL		20	100	I

Inspector ERL

Sludge Merit Rating 9.7

Date ____5-78

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



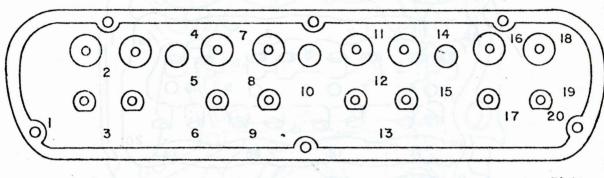
DEPTH		<i>4</i> 00	She	7564	<u>a</u> E					S	TE									JF.	TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	3	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
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Inspector ERL 5-78

Date-

Sludge Merit Rating 9.7

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



Right

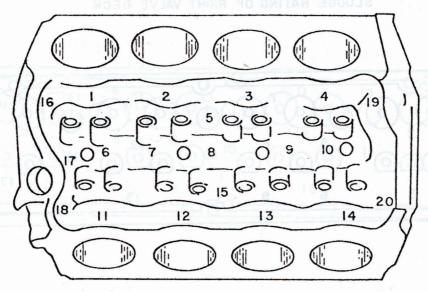
DEPTH		A	0	اليا	ATO	T				S	TE						=-				TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
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AB													and one										
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Inspector — ERL

Date — 5-78

Sludge Merit Rating $\frac{9.7}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right}}{2} = \frac{9.7}{2}$

Rating Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER

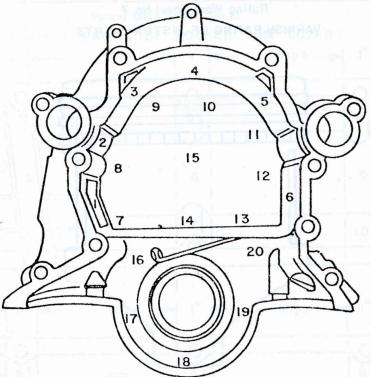


Note: Sites on Vertical Surfaces at Mid-Point

SCALE	1	SITE														TOTAL	%	VOLUME					
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CLEAN																							leas n
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3/4A																							JAPAE
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	Olliville Collina	
Inspector ERL		Sludge Merit Rating 9.7
5-78		

Rating Work Sheet No.6
SLUDGE RATING OF TIMING GEAR COVER



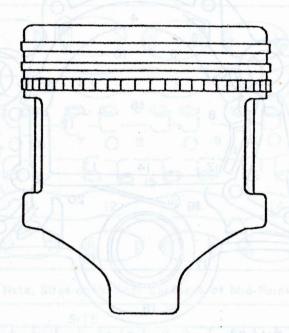
Note: Sites on Vertical Surfaces at Mid-Point

DEPTH		SITE														A CONTRACT	TOTAL	%	VOLU				
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
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Date _______5-/8

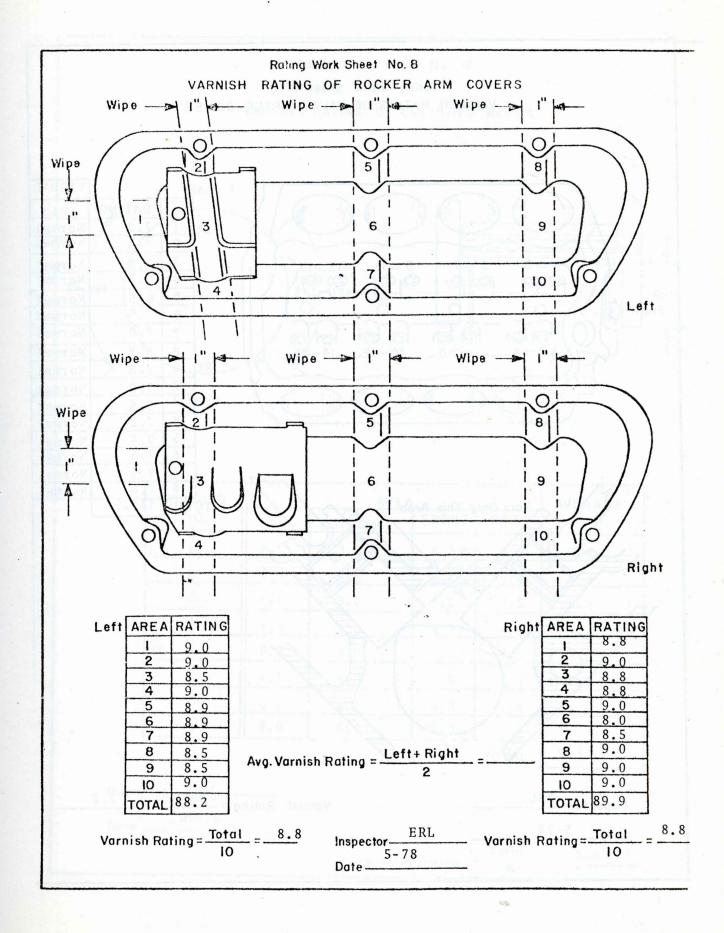
Sludge Merit Rating 9.1

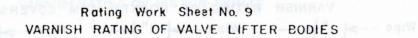
Rating Work Sheet No. 7
VARNISH RATING OF PISTON SKIRTS

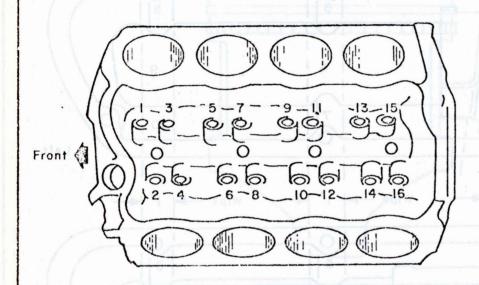


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
	Lt 1	6.0	6.5	6.3	Normal
	2	5.8	5.9	5.9	Normal
	* 3	5.5	5.7	5.6	Normal
	4	5.6	5.9	5.8	Normal
	Rt 1	6.9	5.8	6.4	Normal Normal
	2	6.4	5.4	5.9	Normal
	3	6.0	5.4	5.7	Normal O
	4	6.0	5.4	5.7	Normal
	TOTAL	48.2	46.0		3
	AVERAGE	6.0	5.6		

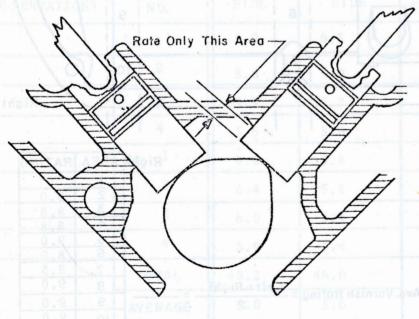
Inspector	VARNISH RATING = AvgThrust + Avg Antithrust =	5.8
Date	ORANO - 2 JAB notasqu	







			VISUAL
	M	RATING	WEAR
Lt	1	7.0	Norma1
	2	7.5	Normal
	3	7.5	Normal
-	4	6.5	Normal
-[5	6.5	Normal
	6	7.0	Normal
	7	7.0	Normal
A	8	8.0	Normal
Rt	1	7.3	Normal
	2	7.0	Norma1
8	3	7.5	Norma1
	4	7.2	Normal
	5	7.5	Normal
1	6	7.5	Normal
dos	7	7.5	Normal
	8	7.0	Normal
TO	TAL	115.5	



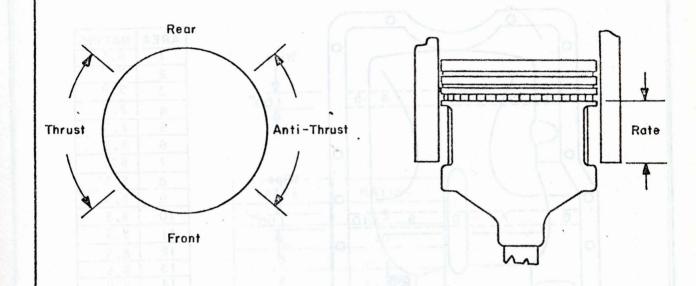
Inspector ERL

Date ______5-78

Varnish Rating = Total = 7.2

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



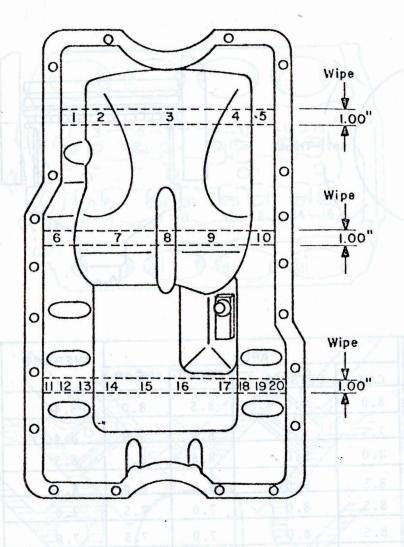
CYLINDER		ARE	4		AVERAGE		
NO.	CAM	OUTSIDE	FRONT	REAR	15 5111		
Lt 1	8.0	9.0	8.5	8.0	8.4		
2	7.5	8.5	8.5	9.0	8.4		
3	8.0	9.0	8.5	8.5	8.5		
All All	8.5	9.0	8.0	8.0	8.4		
Rt ¹	8.5	8.0	7.0	7.5	7.8		
2	8.5	8.0	7.0	7.5	7.8		
3	9.0	8.5	8.0	7.5	8.3		
4	8.0	8.0	8.0	7.5	7.9		
Dota				TOTAL	655		

Inspector ERL

Date _____5-78

Varnish Rating = $\frac{\text{Total}}{8} = \frac{8.2}{}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
The	8.5 9.0
2	9.0
3	9.0
4	8.5 8.5
5	8.5
6	8.5
7	8.5
8	8.5
9	8,5
10	8.5
11	8.5 8.5 8.5 8.5 8.5 8.5
12	8.5
13	8.5
14	9.0
15	9.0
16	8.5 9.0 9.0 9.0 9.0
17	9.0
	8.5
19	
20	8.5
TOTAL	173

Inspector ERL

Varnish Rating = Total = 8.7

Date ______

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

VALVE	RATING
Ltaliona	7.5
2	7.0
3	5.5
4	6.0
Rt ¹	8.0
2	7.0
3	7.5
4	7.3
TOTAL	558

Visual Observation of Seat, recession, or burning: All normal

Avg. Rating= $\frac{\text{total}}{8} = \frac{7.0}{}$

Inspector _	ERL	raidus it
Date	5-78	

	VALIVE PATING	
\		
	0.5	

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A17687

Engine Type:

AMC,360 CID 48,285

Miles:

Oil Type:

MORCO Rerefined

Oil Drain Interval: 4000 mi for 21,000 miles 8000 mi for balance

Sludge Deposit*

Varnish Deposits*

Rocker Arm Covers Intake Manifold	9.7 10.0	Piston Skirts Rocker Arm Covers	9.8
Oil Pan	9.7	Valve Lifters	7.9
Valve Deck Area	10.0	Cylinder Wall (BRT)	9.5
Push Rod Chamber	10.0	Oil Pan	9.9
Timing Gear Cover	10.0		
AVG. SLUDGE	9.9	AVG. VARNISH	9.0

Additional Ratings*

Stuck Valve Lifters Stuck Compression Rings	0	Piston Varnish, Max. 9. Piston Varnish, Min. 9.	
Stuck Oil Rings	0	Intake Valve Deposits, Max. 9. Intake Valve Deposits, Min. 5.	
		Intake Valve Deposits, Avg. 7.	

Clogging

Push Rods, No. Oil Ring, % 0 0 Oil Screen, %

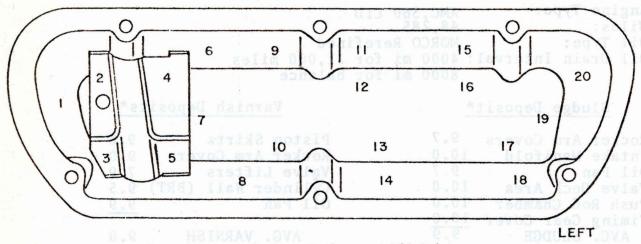
Observations, Comments

Date: 5-78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



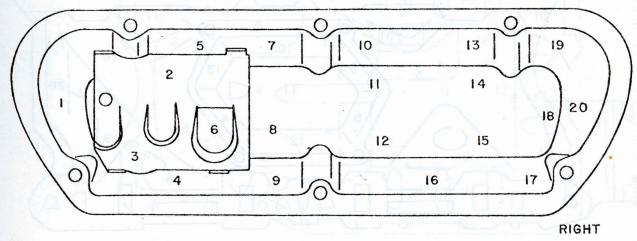
Note: Sites on Vertical Surfaces at Mid-Point

DEPTH										SI	TE	ni	63	. [EII	tio	ib	b _A			TOTAL	%	VOLUM
SCALE	!	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN		5				. (E)	14	d	ei.	DE E	٧	0.0	8.	9				a	g.a.	Я	ession	Compr	Stuci
1/44	x	х	x	x	x	x	x	x	x	x	x	x	x	x	х	x	x	х	x	х	20	100	.25
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Date 5-78

Date: 5-78
Rater: E.R. Lyons

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

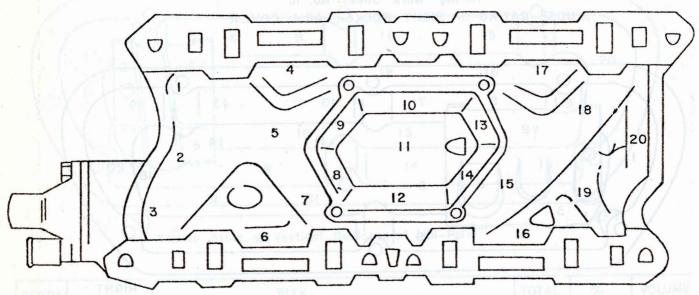
DEPTH				aol				T.		SI	TE		apl.	12	En!	06	EF	0.0			TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN																							
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Inspector — ERL

Date — 5-78

Sludge Merit Rating $\frac{9.7}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right}}{2} = \frac{9.7}{2}$

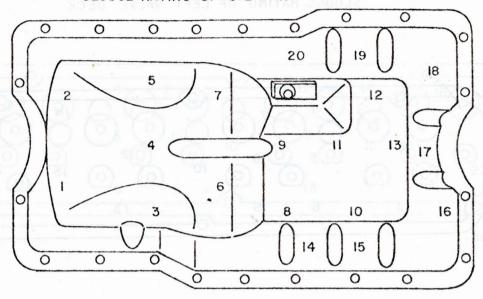
Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD



DEPTH										SI	TE										TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTOR
KABID	x	x	x	х	x	x	x	x	х	х	x	x	x	х	x	x	x	х	х	x			
1/4A																							
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Sludge Merit Rating $\frac{10.0}{}$

Rating Work Sheet No. 3 SLUDGE RATING OF OIL PAN



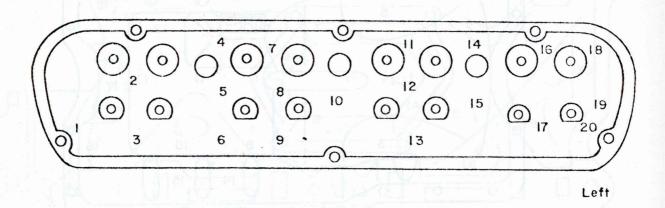
DEPTH										SI	TE										TOTAL	%	VOLUX
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	21/1	2		SID	s b	N B			(- b		6 6	ų ž									14/6/	외기시원	ide j
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Inspector ERL

Date 5-78

Sludge Merit Rating 9.7

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK

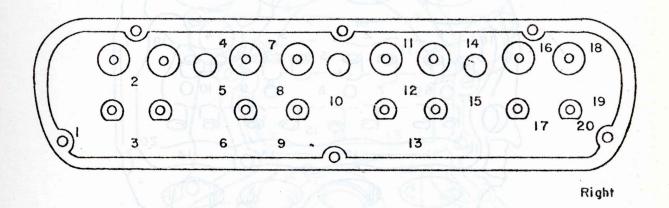


DEPTH	3/6	391			19			NX		S	TE	dip	1/3	H	ule e	H			blia	1	TOTAL	%	VOLUE
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	х	x	х	х	x	x	x	х	x	х	х	х	x	x	x	x	х	x	x x	i Al Ai	NI FE
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Inspector ERL
Date - 5-78

Sludge Merit Rating 10.0

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



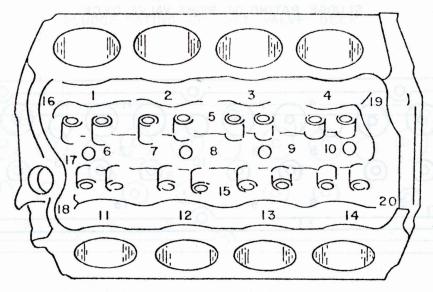
DEPTH	99	T.O	والم	£03	40	- Ac	las	Ta:	To	S	TE			Test	Ex	lai	La	La	15	La	TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	x	х	x	x	х	х	x	х	x	x	х	x	x	х	x	х	x	x			ANY
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Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{10.0}{2}$ Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2}$

Rating Work Sheet No.5
SLUDGE RATING OF PUSH ROD CHAMBER

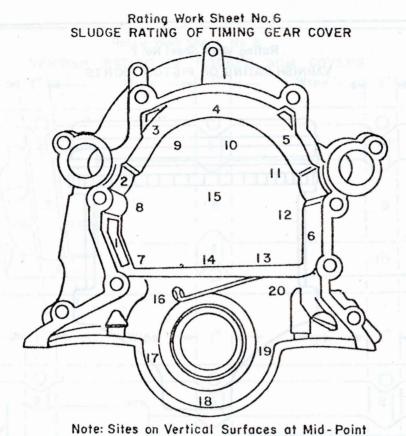


Note: Sites on Vertical Surfaces at Mid-Point

DEPTH										S	TE						-				TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAH	x	х	x	x	x	x	x	x	x	x	x	x	x	х	x	x	x	x	x	x			
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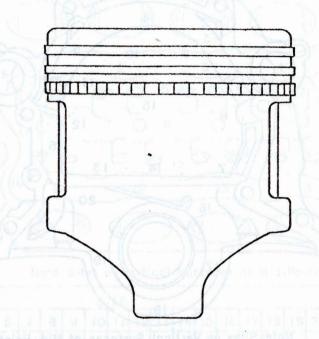
	GRAND TOTAL
Inspector ERL INTERIOR	Sludge Merit Rating $\frac{10.0}{}$
Date5-78	

Avg. Studge Metit Hatting - Lethingight



DEPTH	ŖΠ	1.1	:03		113					SI	TE										TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	x	x	x	x	x	х	x	х	х	x	х	x	x	х	х	х	х	х	x	177	bianas	
1/4A											n			(In	Ď					T	•	/Tagme	
1/2A																						1105319	M
3/4A					CH	8	6			- 2	ę			18								camsid	
Α			es les			- 20				ş				В	10	.5			À		74	liames	
AB		15																	. 1	151	Arga	Ballie.	s/
В	1	4			o i	E	18				- 10												
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С	Γ					8	0			8	0			7	g							n kamao	
D					2	-0									۵					,		TAMPE IS	
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G										1	, 6		*	- 18	. 0	-		EO A	8.3	iΑ.			
н											T B		7.0		0 7			04		JTA	19120	* [] *	
	14	200.0	Litte	10	0.1	13	an	1000										7			-19 a re	leggen!	9.1
In	spe	cto	r_I	RL						O PH	1/43		- 11	HEAT	G	PΛN	מו	TO	TAI	L	81.5	Dotte	
	ate			- 78											G	RAN	4D	TOT	TAL S	luda	e Merit F	Rating $\frac{10}{}$.0

Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS



OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
♥. lt. scuff camside	Lt	9.9	9.9	9.9	Normal
Normal	2	9.8	9.8	9.8	Normal
1t scuff camside	.* 3	9.8	9.8	9.8	*
lt scuff camside **	4	9.8	9.8	9.8	Normal
v. lt scuff outside	Rt 1	9.9	9.9	9.9	v. light scratch
Normal	2	9.8	9.8	9.8	Normal
Normal	3	9.7	9.8	9.8	Normal 0
1t scuff camside	4	9.8	9.9	9.9	Normal
	TOTAL	78.5	78.7		
	AVERAGE	9.8	9.8		

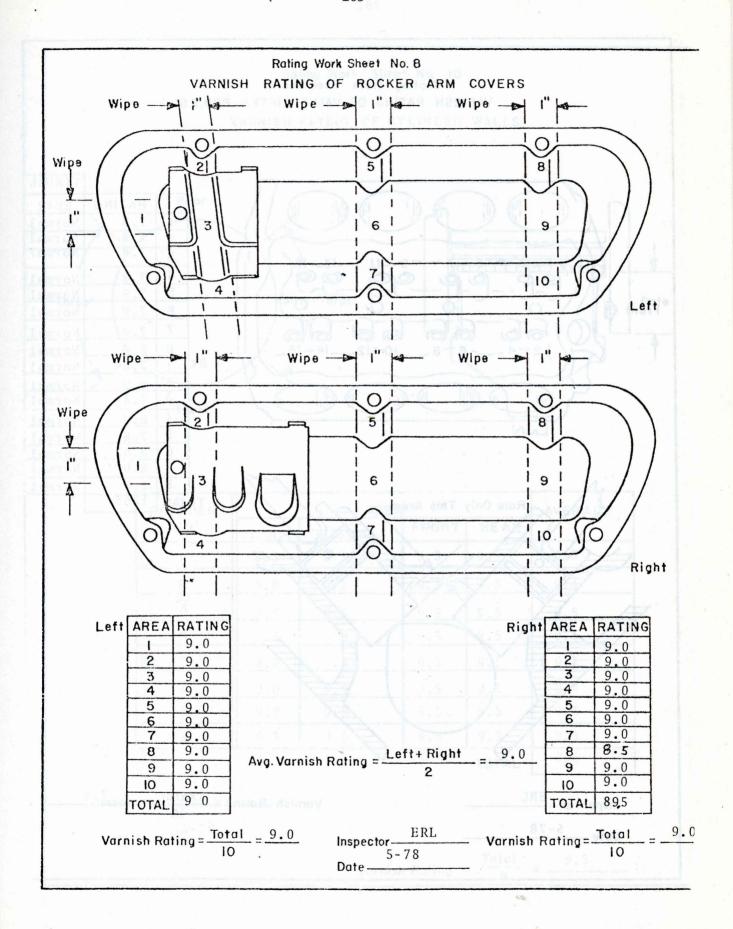
* Distress marks from foreign material, also on crank

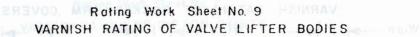
Inspector <u>ERL</u>

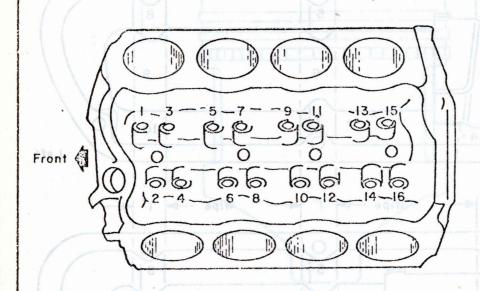
VARNISH RATING = AvgThrust + Avg Antimrust = 9.8

2

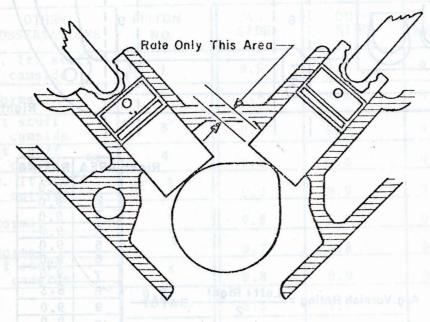
** 15% OF FACE MATL MISSING from # 1 Compress. Ring







			VISUAL
	-11	RATING	WEAR
Lt	1/	7.8	Norma1
U	2	7.8	Normal
11	3	7.8	Normal
4	4	7.8	Norma1
	5	7.9	Normal
	6	7.9	Normal
	7	7.9	Norma1
	8	8.0	Normal
Rt	1	7.8	Normal
	2	8.0	Normal
0	3	7.8	Norma1
S	4	8.0	Normal
	5	7.8	Normal
	6	8.0	Normal
	7	8.0	Normal
8	8	8.0	Norma1
TO	TAL	1263	



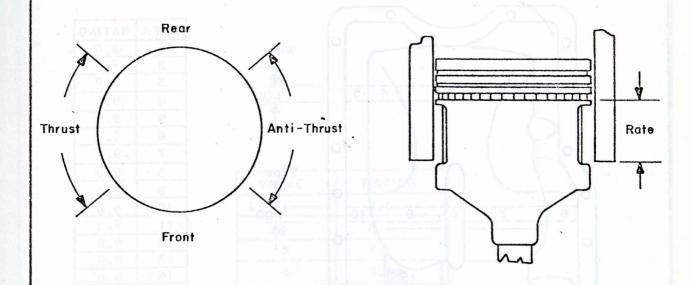
Varnish Rating = $\frac{\text{Total}}{16} = \frac{7.9}{}$

Inspector ERL

Date ______5-78

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



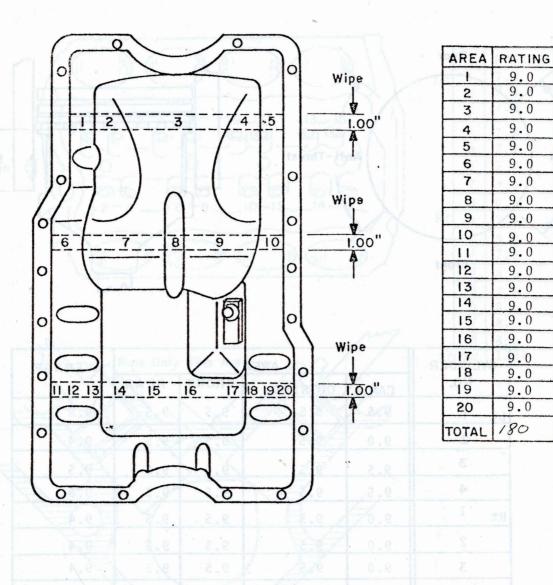
CYLINDER		AREA			
NO.	CAM	OUTSIDE	FRONT	REAR	TET STIT
Lt	9.5	9.5	9.5	9.5	9.5
2	9.0	9.5	9.5	9.5	9.4
Observation	9.5	9.5	9.5	9.5	9.5
4	9.5	9.5	9.5	9.5	9.50
Rt 1	9.0	9.5	9.5	9.5	9.4
2	9.0	9.5	9.5	9.5	9.4
3	9.0	9.5	9.5	9.5	9.4
4	9.5	9.5	9.5	9.5	9.5
-Diffe more				TOTAL	756

Inspector	ERL	Hor
	WA:	

Date _____5-78

Varnish Rating = $\frac{\text{Total}}{8} = \frac{9.5}{}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



Inspector ERL

Date _____5-78

Varnish Rating = Total = _

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0

9.0 9.0

9.0

9.0

9.0

9.0

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

VALVE	RATING
Lt I	8.0
2	8.5
3	5.5
4	9.0
Rt ¹	8.5
2	6.5
3	7.0
4	6.0
TOTAL	590

Visual Observation of Seat, recession, or burning: All normal

Avg. Rating = $\frac{\text{total}}{8} = \frac{7.4}{}$

Inspector _	ERL		
Date	5-78	1	Spint

Rating Work Sheat No. 11 Rating Work Street No. 11 RATING TOWNSHIPSORES

O VALVE RATING			
10 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3			
10 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
10 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
10 3 4 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6			
10 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
10 3 4 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6			
10 3 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
10 3 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9			
2 8 8 2 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
S			
5 5.5 6 13 9.0 6 15 15 15 15 15 15 15 15 15 15 15 15 15			
nal Observation of Seat, recession, . Avg. Refing toldl 7.			

Inspactor. 1971

3-74

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A17685

Engine Type:

AMC, 360 CID

Miles:

60,174

Oil Type:

MORCO Rerefined

Oil Drain Interval: 4000 mi for 21,000 miles

8000 mi for balance

Sludge Deposit*

Varnish Deposits*

Rocker Arm Covers Intake Manifold Oil Pan Valve Deck Area Push Rod Chamber	9.7 9.9 9.7 10.0 10.0	Piston Skirts Rocker Arm Covers Valve Lifters Cylinder Wall (BRT) Oil Pan	9.5 8.5 7.6 8.8 9.0
Timing Gear Cover AVG. SLUDGE	$\frac{10.0}{9.9}$	AVG. VARNISH	8.7

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max.	9.6
Stuck Compression Rings	0	Piston Varnish, Min.	9.0
Stuck Oil Rings	0	Intake Valve Deposits,	
		Intake Valve Deposits,	
SEAR LILL III		Intake Valve Deposits,	Avg. 4.1

Clogging

0 Push Rods, No. Oil Ring, % Oil Screen, % 0

Observations, Comments

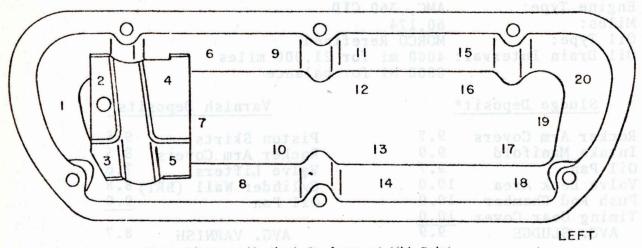
Most of the parts rated had been splattered with aluminum paint during mishap at teardown location.

Date: 5 - 78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH					***************************************					SI	TE	IJI	SM	16	no.	III	Do	A			TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
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1/44	x	x	х	X	x	х	x	x	x	x	x	x	x	x	х	х	х	х	х	х	20	100	.25
1/2A			W		ts	120	qe	Œ	a V	BV	9	ak	į g	, .									
3/4A																							
Α																							
AB																					3	diggof	
В																					No.	Pode	(and
ВС																	,				1 8	Ring	110 :
С												*									8 e	Screen	IIO
D																							
E										- 1	-												
F																							
G																	-						
Н			1						ts	ner	tmc	0	S	τοΙ	J B	VI)Se	0					-
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													. 11	oii	6	RAN	10	TOT	TAI	33	20	100	.25

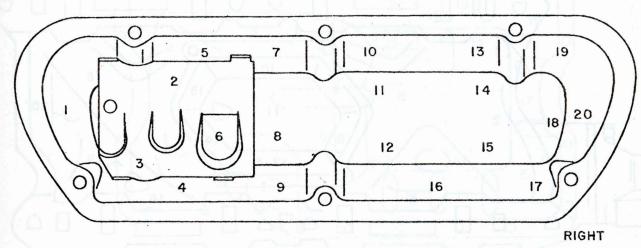
	QUAIAD	IOIAL L			
Inspector ERL		Studge	Merit	Rating	9.7

Date 5-78

Date: 5-78 Rater: H.R. Lyons

10=Clean

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

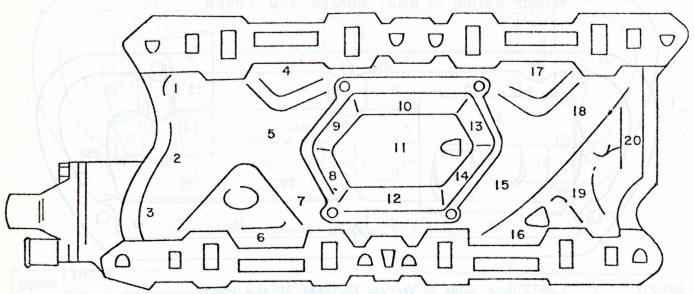
DEPTH					110	ri.				S	TE			 		akii	al.			9 21	TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN		G.						-11			k	X.							71		Toxi(×	411411	IKA BUD
1/4A	x	x	х	x	x	x	x	х	х	х	х	x	х	х	х	х	x	x	х	х	20	100	.25
1/2A																							HASNI
3/4A					Ť																		TARKE
A																				II			T A
A8																						111	N BA
В						- #													12				11 8
ВС																							106
С						1										71							11 3
D						- 1	-													11			1 9
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F																	1						11 9
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																					7		11
30.					PS			10.5	rena	-51	A IS PO			-	6	RAN	nu	TO	ΓΔΙ		20	100	.25

Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.7}{9.7}$ Avg. Sludge Merit Rating $\frac{9.7}{2}$

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

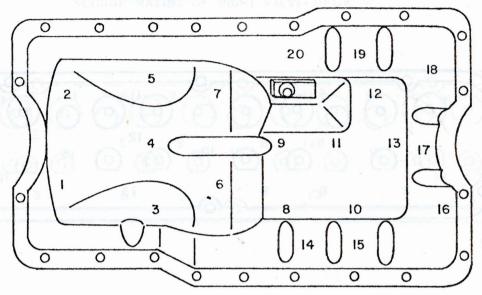


DEPTH		L.A.			ito					SI	TE					374	3				TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	x	х	х	x	x	x	x	X							x	x	x	х	х	х	14	70	CLEAN
1/4A		0.0			0.8				x	x	x	х	x	х	7	X	K	IC.		χŢ	6	30	.08
1/2A																							ASVI
3/4A																							SPA
Α																					1 }		Д
AB																							8 A
В																							. 8
вс																							56
С																							1.2
D																							0.
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F																							1 3
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hea			Ri																	100	NAME OF THE PERSON OF THE PERS		7.1
as lns		01	Е	RL	2.0		*********	JÁ.	101	Q/	IAF	10			G	RAN	1D	TO	ΓAL	•	20	100	.08

Date _____

Sludge Merit Rating 9.9

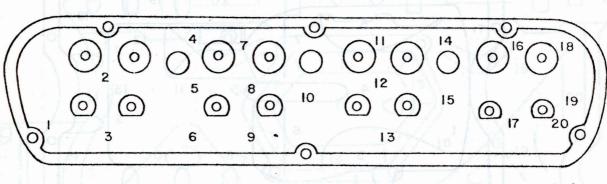
Rating Work Sheet No. 3 SLUDGE RATING OF OIL PAN



DEPTH										SI	TE								-		TOTAL	%	VOLUE
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN							and A				×							X			clx lx	X X X	
1/4A	х	х	х	х	х	х	х	x	x	x	X	x	x	х	x	х	x	х	x	x	20	100	. 25
1/2A	A 30				in Jee								- 21										CV
3/4A																	5.379						P/ 6
Α															To the								
AB					No.											27							a a
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С																							3
D																							0
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н			de mont												TOD						1-1-		H
																					7-7-	200 000 00	
	In	sne	cto		ERI	J	LA'	101	100	AR.	0		nud are		G	RAN	ND	TO	TAL		udge Mar	it Rating	9.7

Date ____5-78

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



Left

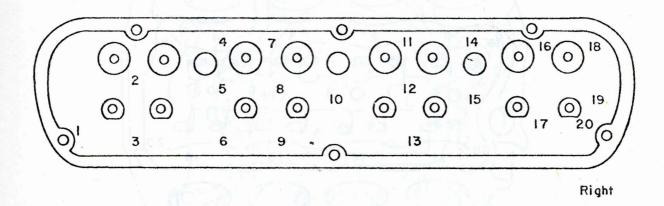
DEPTH			1.1	ATQ			i			SI	TE					2 -					TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	х	х	х	х	х	х	х	x	x	х	х	х	x	x	x	х	х	х			3.10
1/44				18		X			X			974		7.4			A				19-17		<u>e\-</u> -
1/2A																							SYL
3/4A																							3/8
Α			Line																				A
AB						-11	1									44		4					BA
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L	L		L		Į.			da.	_di	AS					G	RAN	ND	TOT	TAL		an in		in st

Inspector ERL

Date _____

Sludge Merit Rating $\frac{10.0}{}$

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



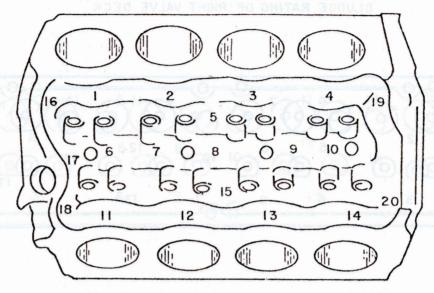
DEPTH		18 N 18 N	وأدد		101	-				S	TE		T						7		TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	х	х	х	x	x	x	х	x	x	х	х	х	x	х	х	x	х	x			
1/4A		114.1																			1-75		
1/2A										- 1-1	9											The first files	The second
3/4A																					1-1-1		
Α																+	- 1						
AB		+																					
В																							-
ВС																			-				17
С							-		-							4							
D											-1	4		-11									
E																							
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Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{10.0}{2}$ Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2}$ $\frac{10.0}{2}$

Rating Work Sheet No.5
SLUDGE RATING OF PUSH ROD CHAMBER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH										SI	TE								-	y y	TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	x	х	х	х	х	х	х	х	х	х	x	х	х	х	х	х	х	x	x	х			
1/4A																							
1/2A																							
3/4A																							ALAN S
A																							
AB		4																			-		
В		947.76								e u les	Name of Street												
ВС																				-			
С			muna-		an-t-re				-														
D							ajura Did		-						-								
E			gul y																				
F			-	-																			
G			V	egardis.											-			-		-			
н		BE S. S. III		Male			o Carlos				iamber.	-		- 10	-				4				
The Cart																							

Inspector	EKL
Date	5-78

Sludge Merit Rating 10.0

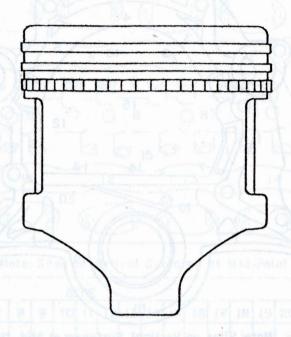
Rating Work Sheet No. 6
SLUDGE RATING OF TIMING GEAR COVER

15
15
12
6
7
14
13

Note: Sites on Vertical Surfaces at Mid-Point

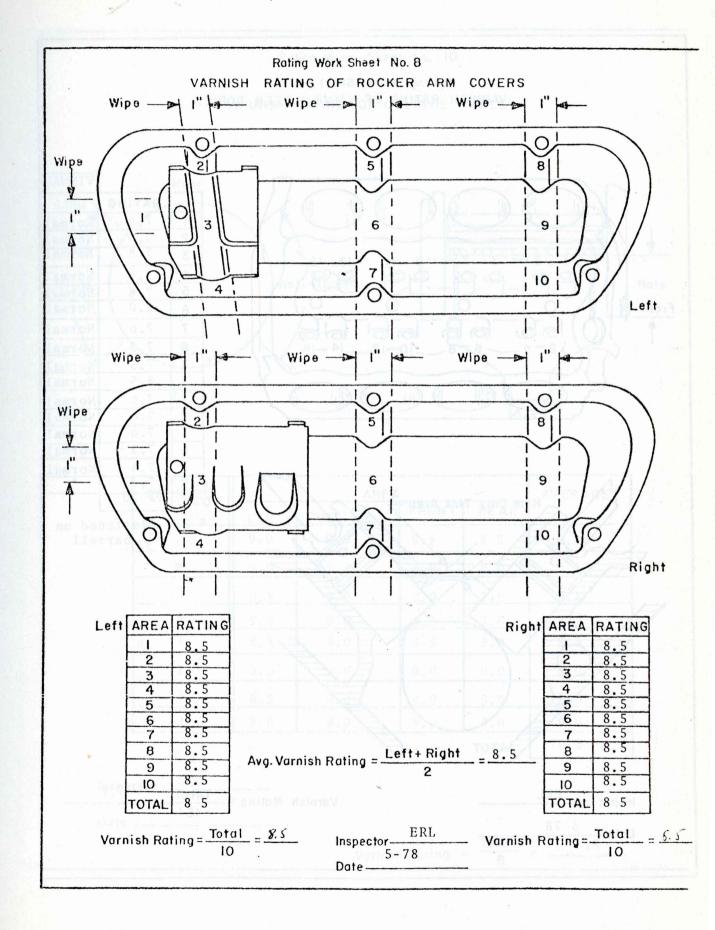
DEPTH										S	TE				12			MA		1	TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACT
CLEAN	X	x	x	x	x	х	Х	x	x	х	х	х	x	x	x	х	x	х	X	х		200	
1/4A						7				7					p					Ī			
1/2A																						- KIT	TT
3/4A	ER	T Q			-10		2			A.	9			9)	10								
Α	BM	tol				1	2,			3	0			8	8	17			À		gyinnin milas —		
AB						11	9			3	a			A	0							1-4-11413	
В																					2.00		
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	spe			RL - 78					•			De			G	RAI	AD	TOT			e Merit F	eating 10	

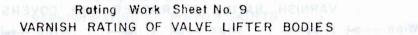
Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

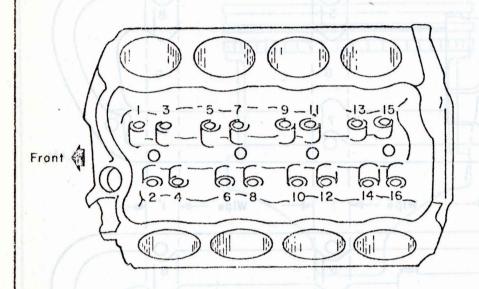


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT~ SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
	Lt	9.3	9.5	9.4	Normal
	2	9.6	9.5	9.5	Normal Normal
	* 3	9.6	9.4	9.5	Normal
	4	9.5	9.3	9.4	Normal
	Rt 1	9.6	9.5	9.5	Normal'
	2	9.5	9.6	9.5	Normal
htiliti	3	9.0	9.5	9.2	Normal
	4	9.3	9.3	9.3	Normal
	TOTAL	75.4	75.6		
	AVERAGE	9.4	9.5	OFAL TEL	

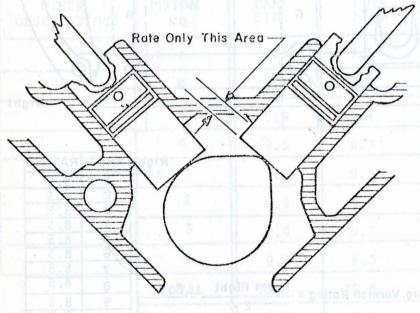
Inspector	AvgThrust + Avg Antithrust	9.5
Date	VARNISH RATING = 2	1







1 2 3	7.6 5.0 7.8	VISUAL WEAR Normal
2 3	7.6 5.0	Norma1
2 3	5.0	
3		Normal
-	7.8	
		Normal
4	7.6	Normal
5	7.8	Normal
6	8.0	Normal
7	7.6	Normal
8	7.9	Normal
1	7.5	Normal
2	,8.5	Normal
3	7.6	Norma1
4	7.6	Normal
5	7.6	Norma1
6	7.5	Norma1
7	7.4	Normal
8	7.8	*
TAL	12 1,0	
	6 7 8 1 2 3 4 5 6 7 8	5 7.8 6 8.0 7 7.6 8 7.9 1 7.5 2 8.5 3 7.6 4 7.6 5 7.6 6 7.5 7 7.4 8 7.8



* S1. Flattened on barrell

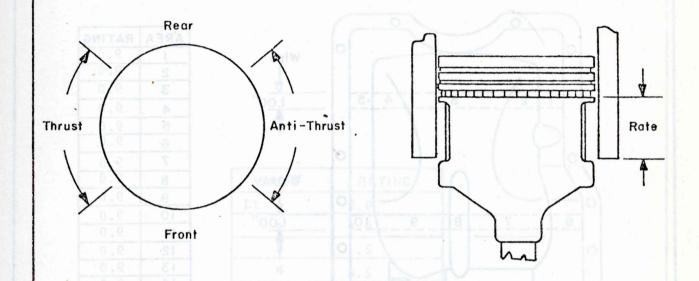
Inspector ERL

Varnish Rating = $\frac{\text{Total}}{16} = \frac{7.6}{}$

Date 5-78

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



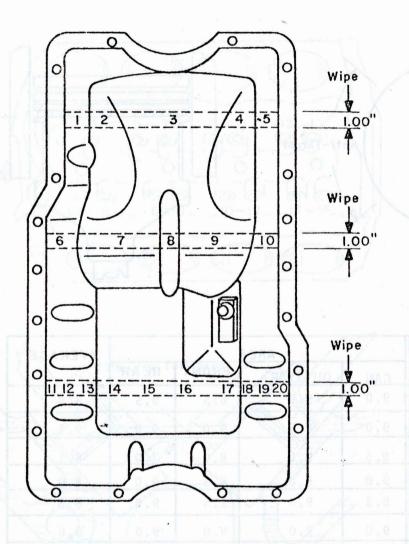
CYLINDER		AREA													
NO.	CAM	OUTSIDE	FRONT	REAR											
Lt ds	9.0	9.0	8.5	8.5	8.8										
1A20T	9.0	9.5	9.0	9.0	9.1										
bser 3 tion	8.5	9.0	8.0	7.0	8.1										
4	9.0	9.0	8.5	9.0	8.9										
Rt ¹	8.5	9.0	8.5	9.0	8.8										
2	9.0	9.0	9.0	9.0	9,0										
3	8.5	9.0	9.0	9.0	8.9										
4	9.0	9.0	9.0	9.0	9.0										
Date				TOTAL	70.6										

Inspector ERL change dainted

Date _____5-78

Varnish Rating = $\frac{\text{Total}}{8}$ = $\frac{8.8}{100}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
1	9.0
2	9.0
3	9.0 9.0
3 4 5	9.0
5	9.0
6 7	9.0
7	
8	9.0 9.0
9	9.0
10 .	9.0 9.0
old -	9.0
12	9.0 9.0 9.0 9.0 9.0
13	9.0
14	9.0
15	9.0
16	9.0
17	9.0
18	9.0
19	9.0
20	9.0
TOTAL	
E	

Inspector ERL

5-78

Varnish Rating = Total = 9.0

Rating Work Sheet No. 12

INTAKE VALVE DEPOSITS

VALVE	RATING
Lt I	3.0
2	4.0
3	1.5
4	8.5
Rt ¹	4.0
2	2.0
3	4.5
4	7.0
TOTAL	33.15

Visual Observation of Seat, recession, or burning: Lt 2 valve seat had very heavy deposit.

Avg. Rating= $\frac{\text{total}}{8} = \frac{4.1}{}$

Inspector _	ERL	i jena
Date	5-78	

Observations: oil seal umbrellas appeared slightly out-of-round to mechanic. Intake ports look washed.

Roting Work Sheet No. 12

	4 34	
	ě .	
ession, had very		

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A17683

Engine Type:

AMC, 360 CID 49,503

Miles:

Oil Type: Virgin Base Stock
Oil Drain Interval: 4000 mi for 23,000 miles
8000 mi for balance

Sludge Deposit*	Varnish Deposits	5*
Rocker Arm Covers 9.9 Intake Manifold 9.8 Oil Pan 9.8 Valve Deck Area 10.0 Push Rod Chamber 10.0 Timing Gear Cover 9.7	Piston Skirts Rocker Arm Covers Valve Lifters Cylinder Wall (BRT) Oil Pan	7.9 8.7 7.3 8.8 9.0
AVG. SLUDGE 9.9	AVG. VARNISH	8.3

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max.	9.1
Stuck Compression Rings	0	Piston Varnish, Min.	6.6
Stuck Oil Rings	0	Intake Valve Deposits, Max.	8.0
		Intake Valve Deposits, Min.	1.5
		Intake Valve Deposits, Avg.	

Clogging

Push Rods, No. Oil Ring, % Oil Screen, % 0 0

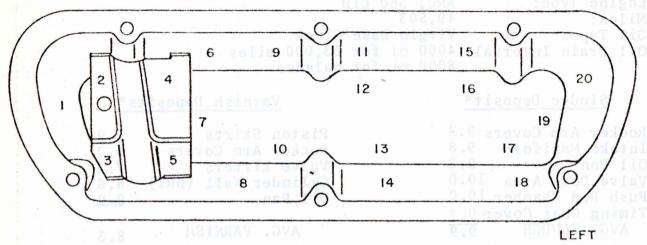
Observations, Comments

Date: 5-78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH										SI	TE	11,3, 3	19.74		RELLY	at the set	4.3				TOTAL	%	VOLUM
SCALE	ı	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	0 .	1		a.r.		T.	х		2 1.0	х	V	х	x	4		х	х	8	x	24.)	7	35	SIIC
1/4A	x	х	x	х	x	x		x	х	İs	x	ozi.		X	х			х		х	13	65	.16
1/2A	2	\$4 14	gv	Ą	e 2.	T. B	00	ne	31	Ls	V	ike	ď	I									
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Α																							
AB																						garago	<u></u>
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ВС																- 74				0		ting, t	LiO
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E																							
F																7							
G												,											
н									3	ne	ntm	OU		MO	13	g V	98	ďŪ					
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			•	A											6	RAN	AD.	TO	ΓΑΙ		20	100	

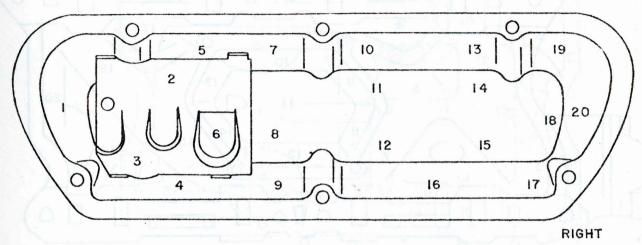
Inspector ERL

Sludge Merit Rating $\frac{9.8}{}$

Date 5-78

Nator: 5-78 Rator: F.R. Lyons

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

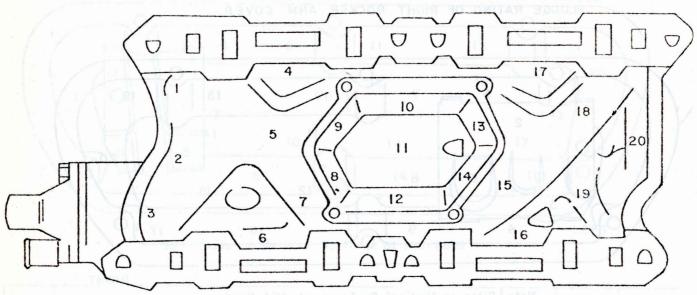
DEPTH	Y		%		10	101				S	TE						THE				TOTAL	%	VOLUME
SCALE	i	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN		х	х			x		x			x	х		Х	х			x		JIX.	9	45	3(863
1/44			1	х	x		х		x	х	100		x	N.		x	x	X	х	x	10	50	.12
1/2A	x													7							1	5	.02
3/4A												I			1								a P
Α																							A
A8																					114-1		41-2/
В						- *												1					_4_3
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F																					44 1		
G																							11.0
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ill at						11			An	01	GH)	ARE			G	RAN	ID.	TO	TAL		20	100	.14

Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.9}{9.9}$ Avg. Sludge Merit Rating = $\frac{\text{Left+Right}}{2}$ = $\frac{9.9}{2}$

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

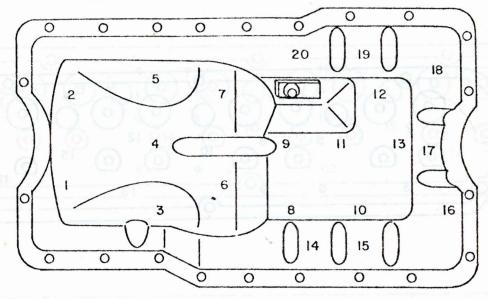


DEPTH										SI	TE										TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
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3/4A																							AA\
Α									Ŧ														
AB																							-88
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F			1																				
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1																					1		
Ins	ign		F	RL		17				01					G	RAI	un.	TO	TAL	dige	20	100	.16

Date 5-78

Sludge Merit Rating 9.8

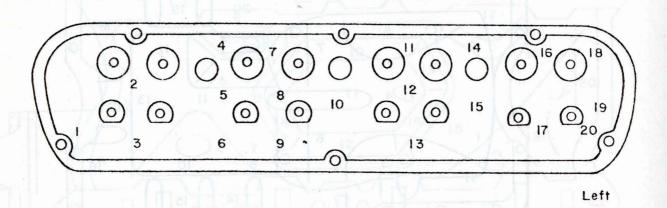
Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN



DEPTH										S	TE				arte					يخاه	TOTAL	%	VOLUE
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х										y		7		y T					2	10	alp
1/4A			x	х	X	X	x	X	x	х	х	x	x	x	x	x	x	X	x	х	18	90	.22
1/2A						1																Д	811
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Α																							
AB								II	4000														ia I
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ВС														*	·								na i-
С																							7
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Inspector ERI

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



DEPTH TOTAL % VOLUX SITE SCALE CHECKS COVERED FACTO 10 11 12 13 14 15 15 17 18 19 20 3 9 CLEAN X $\mathbf{x} \mathbf{x}$ XX x 1/44 1/2A 3/4A A AB 8 BC C D E F G H GRAND TOTAL

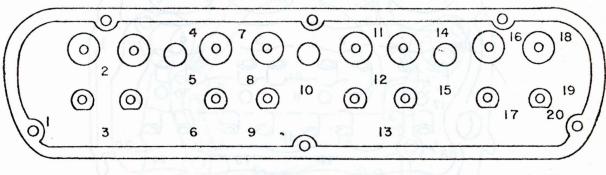
Sludge Merit Rating 10.0

Inspector ERL

5-78

Date ---

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



Right

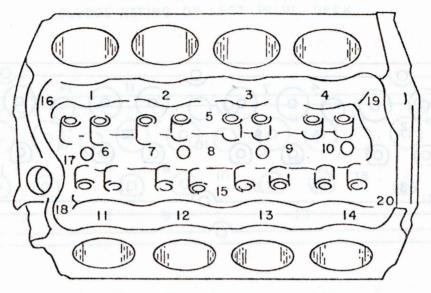
DEPTH		dia.		JAT	OF					S	TE	7000	o de la compansión de l		1	SH					TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	х	х	х	х	x	х	х	х	x	x	x	x	x	x	x	x	х	x	$\int_{\mathbb{R}} \chi d\chi dx$	v (, f x li	(43.0)
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							11																

Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{10.0}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right}}{2}$

Rating Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER



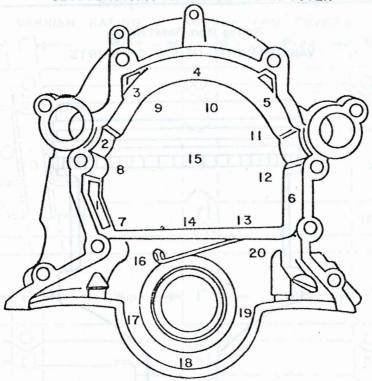
Note: Sites on Vertical Surfaces at Mid-Point

DEPTH		1/9		JA	TOT					S	ITE				à	SIT					TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	x	х	x	х	х	x	х	х	x	x	х	x	x	х	х	х	x	х	х	x	Scheels	Lise bath	AB BY
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Inspector_	ERL
Seletta t	7.0

Sludge Merit Rating 10.0

Rating Work Sheet No.6
SLUDGE RATING OF TIMING GEAR COVER



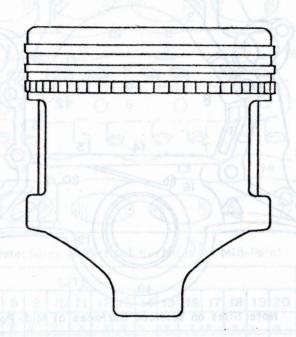
Note: Sites on Vertical Surfaces at Mid-Point

	3 4 x x	C 2	5 6 x x		8 x	9 x	10 x	x	12 x	13 x	14 x	15 x		17 x	18 x	19 x	20 x	CHECKS 20	COVERED 100	FACTO
x 2	x x	I		x	x	x	x	X	х	x	х	х	Х	х	х	х	x	20	100	
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Date ______5-78

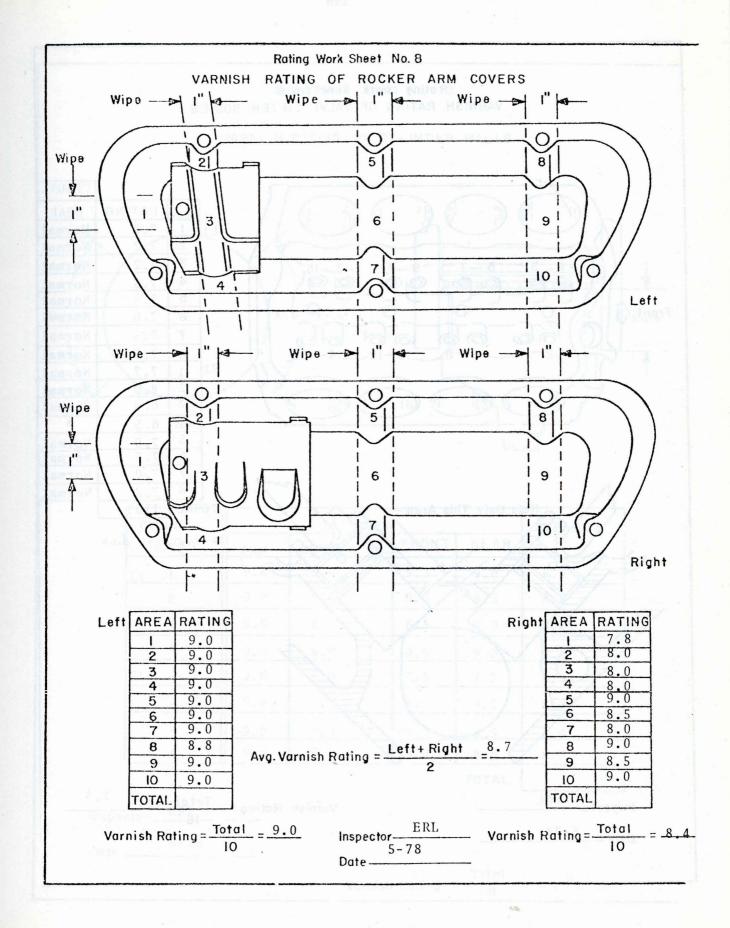
Sludge Merit Rating _____9./

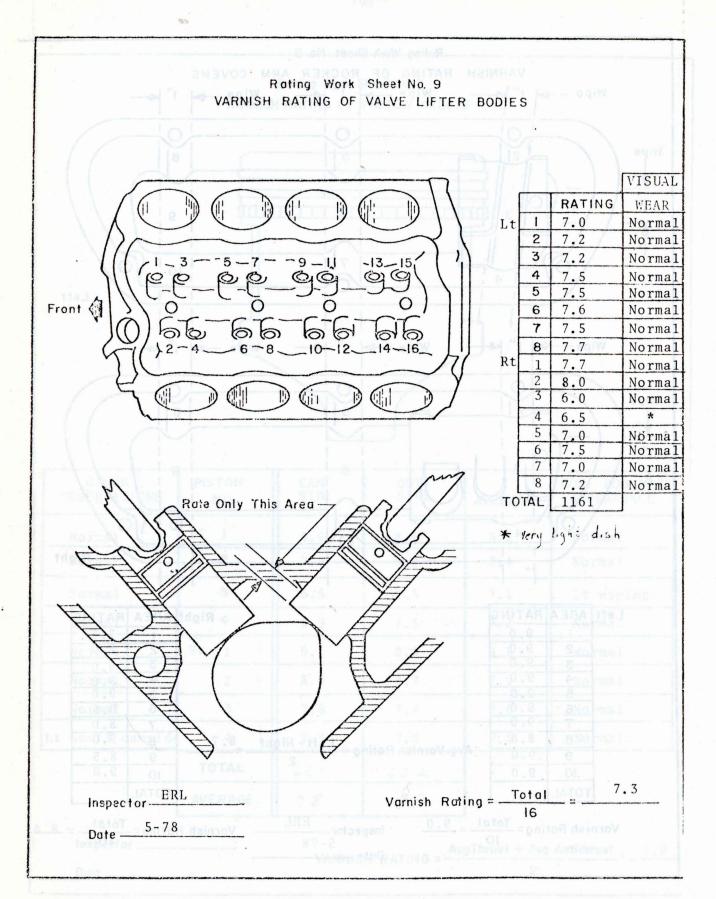
Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS



OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
Normal	Lt	8.0	8.6	8.3	Normal
Normal	2	7.7	9.0	8.4	Normal
Norma1	* 3	6.6	7.5	7.1	Lt wiping
Normal	4	6.9	7.5	7.2	Normal GA
Normal	Rt 1	9.1	8.5	8.8	Normal
Normal	2	8.0	7.7	7.9	Norma1
Normal .	3	7.8	7.4	7.6	Norma1
Lt scuff camside	4	7.9	7.0	7.5	Norma1
	TOTAL	62.0	63.2		
	AVERAGE	2.8	2.9		H

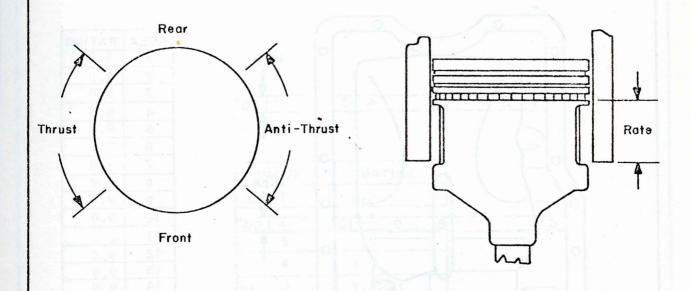
Inspector	VARNISH RATING = AvgThrust + Avg Antithrust 7.9
Date	VARNISH RATING = 2 No. 2 ato 0





Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



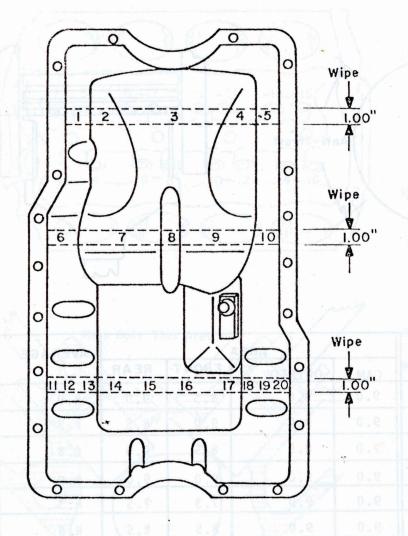
CYLINDER	9015	ARE	Α		AVERAGE
NO.	CAM	OUTSIDE	FRONT	REAR	
Lt I	9.0	9.0	8.5	9.0	8.9
2	9.0	9.0	9.0	8.5	8.9
3	9.0	8.5	8.5	9.0	8.8
4	9.0	9.0	9.0	9.0	9.0
Rt ¹	9.0	9.0	7.5	7.5	8.3
2	9.0	9.0	8.5	8.5	8.8
3	9.0	9.0	9.0	8.5	8.9
4	9.0	9.0	8.0	8.0	8.5
		*		TOTAL	

Inspector_	ERL	
	E 70	

Date ____

Varnish Rating = $\frac{\text{Total}}{8}$ = $\frac{8.8}{1}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



RATING
9.0
9.0
9.0
9.0 9.0 9.0
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9.0
180

Inspector ERL

Varnish Rating = $\frac{\text{Total}}{20} = \frac{9.0}{}$

Date ______

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

VALVE	RATING
Lt I	5.0
2	2.5 Va
3	7.5
4	3.0
Rt 1	1.5
2	7.5
3	4.5
4	8.0
TOTAL	39.5

Visual Observation of Seat, recession, or burning: All Normal

Weter Deck Area

Avg. Rating= $\frac{\text{total}}{8} = \frac{4.9}{}$

Inspector _	ERL		
Date	5-78	i fike ee	

9.9.

Rating, Work Sheet No. 12

STISOSSINE VANVE SHAPPING TO PAN

	1 2 6			
	asion, ', T			
				*

ENGINE INSPECTION SUMMARY

Vehicle I.D.: A17688
Engine Type: AMC, 360 CID

Miles: 54,477

Oil Type: Virgin Base Stock Oil Drain Interval: 4000 mil 4000 miles for 22,000 mi 8000 miles for balance

Sludge Deposit	*	Varnish Deposits	*
Rocker Arm Covers	9.6	Piston Skirts	6.0
Intake Manifold	9.7	Rocker Arm Covers	6.2
Oil Pan	9.8	Valve Lifters	5.0
Valve Deck Area	10.0	Cylinder Wall (BRT)	6.1
Push Rod Chamber	9.9	Oil Pan	8.1
Timing Gear Cover	10.0		
AVG. SLUDGE	9.8	AVG. VARNISH	6.4

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max. 6.5
Stuck Compression Rings	0	Piston Varnish, Min. 5.5
Stuck Oil Rings	0	Intake Valve Deposits, Max. 8.0
		Intake Valve Deposits, Min. 5.0
		Intake Valve Deposits, Avg. 6.6

Clogging

Push Rods, No. Oil Ring, % Oil Screen, % 0

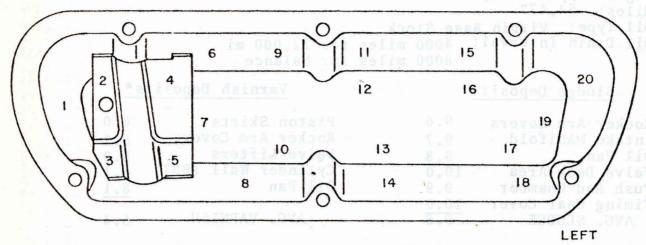
Observations, Comments

Some light rust on valve lifters.

Date: 5 - 78

Rater: E.R. Lyons

* 10=Clean



Note: Sites on Vertical Surfaces at Mid-Point

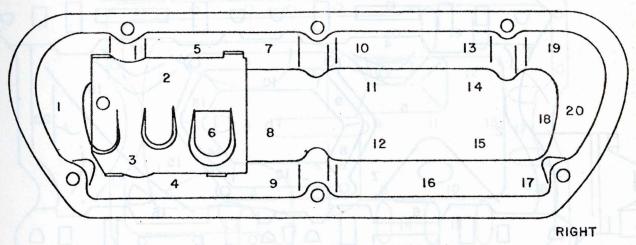
DEPTH										SI	TE	20.70		- (1						-	TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
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1/2A		x		х	x		x										x	x	х	х	8	40	.20
3/4A			х																		1	5	.04
Α	x																				1	5 00	.05
AB																							
В				-		- 14															0 .07	Rods	Push
ВС																7					Q	neero	1 f ±0
С				-																			
D																							
E																							
F																							
G									3.	ms	avas	Co		uo	ij	s v n	0.8	40					
Н				1														-					
1					1										71	33	li	91	[E	V I	rust o	light	Some
			,													RAN	ID.	TO	- A1		20	100	.41

Inspector ERL

Sludge Merit Rating 9.6

Date ______

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



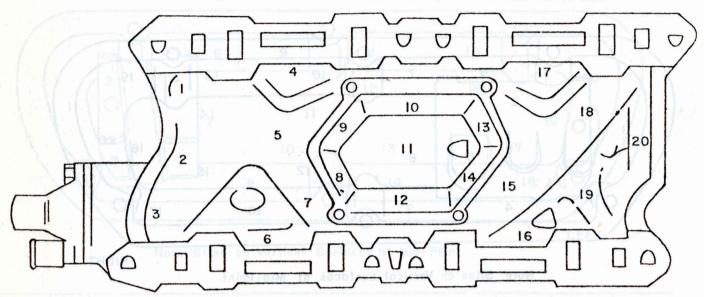
Note Sites on Vertical Surfaces at Mid-Point

DEPTH										SI	TE			The state of the s							TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN			a yro	D P	1.45	TRA	83	18.1	10	15	0.83	18	36		48		12		1,8		9161		
1/44	x		х	x		x	х	х	х			х	x	x	x		1	x	x	х	14	70	.18
1/2A		x	Day		x	I		IX.	4 3	x	x				- IX	x	x	. LX		4	6	30	.15
3/4A														1									AST
Α																							The second
8A			7	1															1				and the same of
В						-4																	11 57
ВС																							
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D																		Щ		4			
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G								The second											1				
н								1									Ц			4			11.2
1								Total Section 1							- 1				18				-11-H
							II							1	G	RAN	ID.	TO	TAL		20	100	.33

Inspector ERL 5-78

Sludge Merit Rating $\frac{9.7}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right}}{2}$

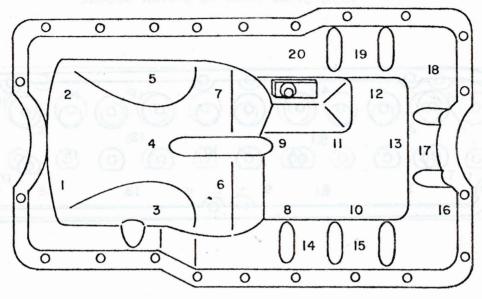
Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD



DEPTH		date	40	he	1.6	43		TI.	11	SI	TE				14						TOTAL	% COVERED	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS		FACTOR
CLEAN								18						18	12.						<u> </u>	$y_{x} \perp 1$	III aasti
1/4A	x	x	х	x	х	x	х	x	х	x	x	x	x	x	х	x	x	х	x		19	95	.24
1/2A																							APN
3/4A																							Of A
Α																				x	1	5	. 0.5
AB																							8
В																							1
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С										İ													
D																							
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F																							a
G					X																		
н																							
			-0			ÒS	14			3	310	735			RA	ND.	To	FAI			0 II	0 1	41
Ins	200	tor	E	RL	M	ip bu	H8				4.97				G	RAN	D	TO	TAL	gė	20	100	.29

Sludge Merit Rating 9.7

Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN

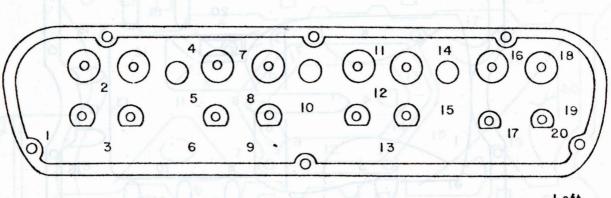


2	3		1					3	TE										TOTAL	%	VOLU)
	1	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
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x x				x	х	x	x	x	x	x	x	х	x	x	x	x	x	х	17	85	.21
				1		Jun 16290	1														15117
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																					8
		1																			oa 1
					Suc mil																
		-				Gara J		COMPANY OF THE PARTY OF THE PAR													10 1
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								- A- H-CH-1									Luna.				
																					9
																			75.1		H
1											-4										
	7					Derte	A STATE			h			G	RAN	in.	TOT	AI	-bank	20	100	9.8
	nspe	specto	nspector	nspector_ERI	aspector_ERL	aspector ERL	aspector ERL	aspectorERL	aspectorERL	aspector ERL				G	GRAN	GRAND	GRAND TOT	GRAND TOTAL	GRAND TOTAL	GRAND TOTAL 20	GRAND TOTAL 20 100

Inspector ERL

Date 5-78

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



Left

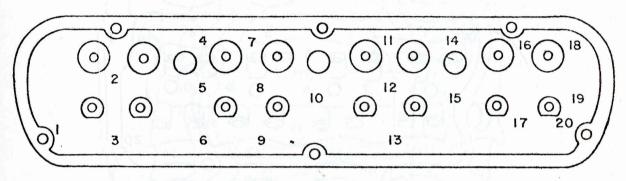
DEPTH	i	P.		ATT	er l				1 0	S	TE				17	8					TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	x	x	х	x	x	х	x	х	X	х	x	х	х	х	х	х	х	х	X X X		3.0
1/44	3			N			ě	X	X	X	7.		X	X.		X		XX	X	X			SAX1
1/2A																							33
3/4A																				4			PAIC
A																				Щ			
AB	1					-47																	dA.
В																			•				0
ВС				1																			38
С																							2
D																							g .
E																							
F								1															
G			V			1																	9 1
н																							16
						1		N.															
		100		0	5	1	٠	TO	7 0	MA	90				G	RAN	Jn.	TOT	rai			WDL_	

Inspector___ERL

5-78 Date----

Sludge Merit Rating 10.0

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



Right

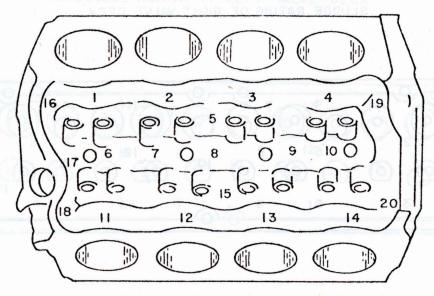
DEPTH	raen		n İ			La			Te	S	TE		ZI.	I	Ť	a dire			Ú.	77	TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	х	x	x	x	х	x	х	х	х	х	х	х	x	х	x	х	х	х	x	х			
1/4A			4	e j								13	1		10								
1/2A							4+															4	A. M. A.
3/4A	En.	e franc			ritor i	Fg					6										!		
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AB					4		-					- 1 h	-12				=				1-1-3		8
В	ne-tre																					7	TIR
ВС	Unantité :		- 1												(- ₇								elina impara in a alimatelia (filo
С		(B)										-d	-47			- 1							- At -
D				pull reg			- V		-	= }	-44				1	+			7		1 = =		
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н				-						es per f													
	my half			de tro-	1	1		-J						- 1	- 1		- 1		- 1	- 3			
Section 1	me	nodinda			- 1	H		A Pi	21	O E TE	i All				G	RAN	מו	TOT	ΔΙ				

Inspector ERL

Sludge Merit Rating $\frac{10.0}{2}$ Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2}$ = $\frac{10.0}{2}$

Date ______5-78

Rating Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER

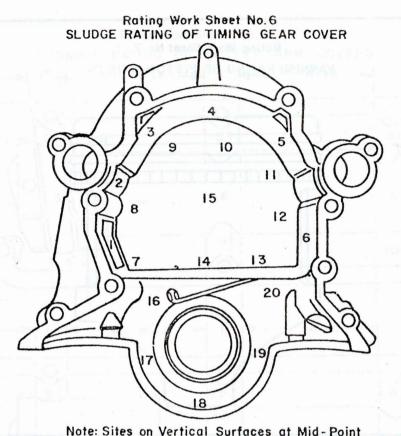


Note: Sites on Vertical Surfaces at Mid-Point

DEPTH						1				SI	TE		Na lamana							e serie	TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	x	x	х	x	x	x	x	х	х	x	х	х	х	x	х	х	x	x		0	18	90	
1/4A									- 2														EAS.L.
1/2A																							A PALL
3/4A																			a 2				ADM
Α											4			1/					x	х	2	10	.08
AB																							
В																							E A
ВС							4						5					2					
С	1	u u																					176
D																				-			
E									yer a														
F						1																	42-
G										et ja													
н					-				- 3														
1										-					-								4"
hamala d						4									G	RAN	ID	TOI	AL		20	100	
	Inc	ne	ctor		EI	3L										GR.	AME) T	OTA	Slu	dae Meri	t Ratina _	9.9

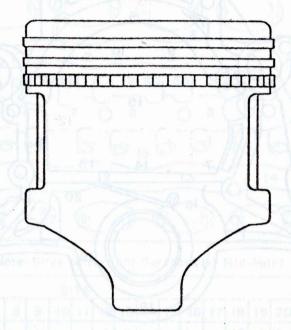
Inspector_ 5-78 Avg. Studge Merit Rotings & 91

Sludge Merit Rating -



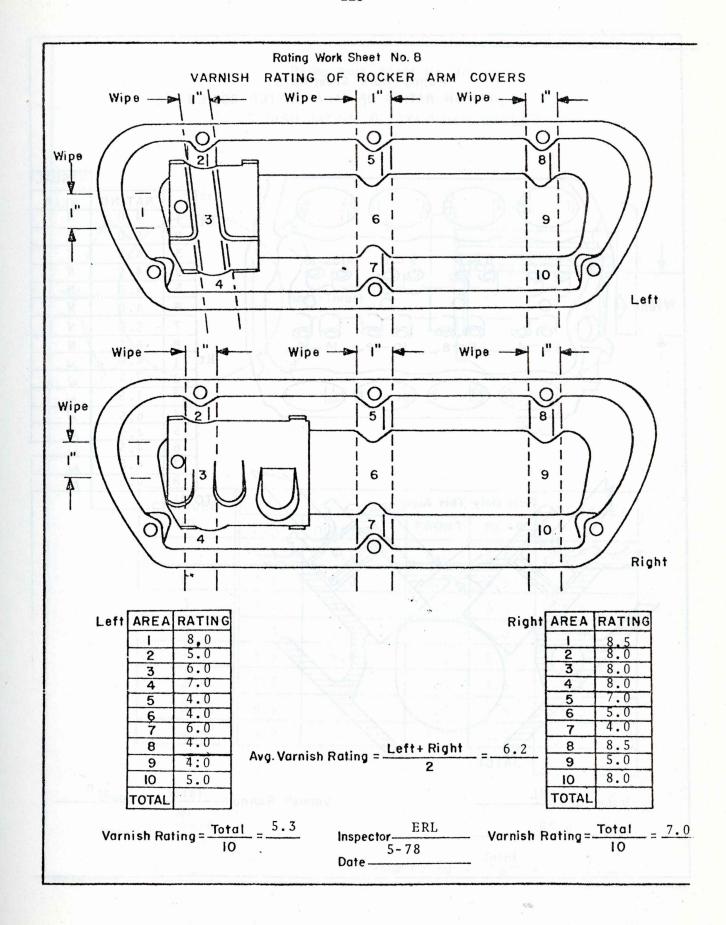
DEPTH		hid	GA		29.6		1		ĺ	S	TE						j				TOTAL	%	VOLU
SCALE	ı	2	3	4	5	6	7	8	9	10	11	12	13	14	Iö	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	x	х	х	x	x	x	x	х	x	х	х	х	х	x	x	х	x	х	x	x	Ito I	10/	
1/4A														0					-9-				
1/2A																			37				
3/4A					- 14	- 4															11 / 18	841	
A					Ė	73	n.C			10	à			I	. 7	9				. Ma	hilare	Algazia	
AB						8.38				à	A.				à				l.	.18			
В															3								
ВС					10		·																
С					10	Ja i				F				7	V.						1		
D			-	7		ja i				ā.				Ŷ,	3				Į.		11.7		
E				6						Dia.		. (4)		9 97	hs.	7 1 -			874	42.		- 4-5	-1
F									-						100.0						1 10		7
G			Ĭ,							1.0								273	AA	, VA	Tor	5.4	
н																							
11.0			r(12)	(B, 1)	or Si	86 P		Pov	A)		1 111			FU /.	(= ·				-4	1.07	in that is	014/20/10/-	
In	spi	ecto	r_E	RL	8										6	RAN	מו	TOT	ΊΔΙ	•		9tb©	

Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

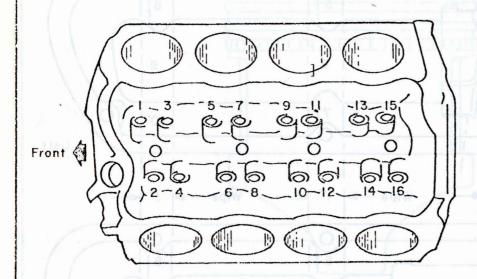


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE
	Lt i	5.7	6.5	6.1	ALL NORMAL
	2	6.1	6.5	6.3	ASS
S1. Tight Pin	3	6.0	5.9	5.9	ASV
	4	5.9	6.0	5.9	THE A
	Rt 1	6.0	6.5	6.2	BA
	2	6.0	6.0	6.0	1 8
Tight Pin	3	5.7	6.4	6.0	
	.4	5.5	6.5	6.0	
	TOTAL	50.3	46.9		
	AVERAGE	5.7	6.3		

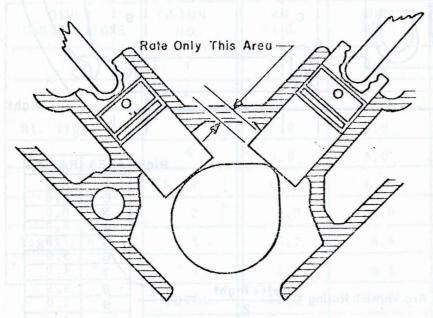
Inspector	VARNISH RATING = AvgThrust + Avg Antithrust =	6.0
Date	MARIO	ni



Rating Work Sheet No. 9 VARNISH RATING OF VALVE LIFTER BODIES



			VISUAL
ſ	6	RATING	WEAR
Lt	1	4.0	N
	2	5.0	N
	3	4.5	N
	4	4.0	N
	5	4.0	N
	6	4.0	N
	7	5.0	N
1)	8	6,5	N
Rt	1	4.0	N
	2 3	. 7.5	N
9		4.5	N
1.9	4	6.5	N
	5	4.5	IN
	6	4.5	N
	7	4.5	N
10	8	6.5	N
ТО	TAL	4	



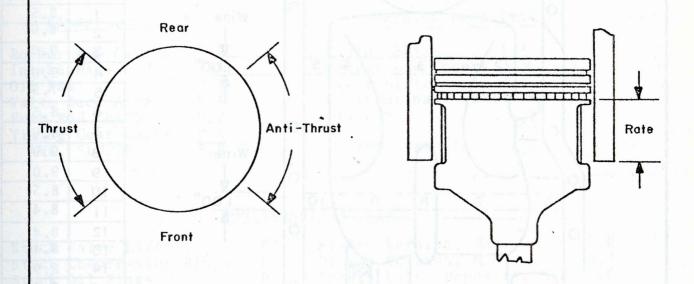
Varnish Rating = Total = 5.0

Inspector ERL

Date ______5-78

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



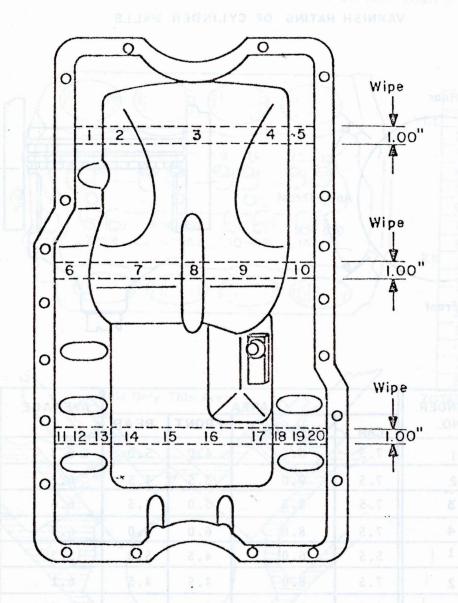
CYLINDER		ARE	Α		AVERAGE
NO.	CAM	OUTSIDE	FRONT	REAR	0
Lt I	7.5	8.5	4.0	5.0	6.3
2	7.5	9.0	3.5	4.5	6.2
3	7.5	8.5	5.0	5.5	6.6
4	7.5	8.0	6.0	6.0	6.9
Rt ¹	5.5	6.0	4.5	5.0	5.3
2	7.5	8.0	4.5	4.5	6.1
3	6.5	7.5	5.0	4.5	5.9
4	6.0	6.0	5.0	4.5	5.4
a rusit on	Tifter		750 Of le	TOTAL	48.7

Inspector __ERL

Date _____5-78

Varnish Rating = $\frac{\text{Total}}{8} = \frac{6.1}{}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
1	8.5
2	and the second s
3	9.0
4 5	9.0 7.5
5	7.5
6	8.5
6 7	9.0
8	9.0
9	9.0
10	9.0 8.5 8.4
-11	
12	8.4
13	8.4
14	8.9
15	8.4 8.4 8.9 8.9 8.9
16	
17	8.9
18	8.5
19	8.5
20	8.5
TOTAL	1723

Varnish Rating =
$$\frac{\text{Total}}{20} = \frac{8.6}{100}$$

ENGINE INSPECTION SUMMARY

Vehicle I.D.: A20371

Engine Type: Ford F-750, 361 CID

Miles: 27,207

Oil Type: Virgin Base Stock

Oil Drain Interval: 4000 mi

Sludge Deposit	*	Varnish Deposits*
Rocker Arm Covers Intake Manifold Oil Pan Valve Deck Area	9.3 9.4 9.5 6.2	Piston Skirts 6.4 Rocker Arm Covers 3.6 Valve Lifters 7.3 Cylinder Wall (BRT) 7.0
Push Rod Chamber	9.7	0il Pan <u>6.2</u>
Timing Gear Cover AVG. SLUDGE	$\frac{9.5}{8.9}$	AVG. VARNISH 6.1

	Ad Lator Ad	dition	al Ratings*	
Stuck	Valve Lifters Compression Rings Oil Rings	0 0 0	Piston Varnish, Min. Intake Valve Deposits, Max.	7.0
			Intake Valve Deposits, Min. 6 Intake Valve Deposits, Avg. 7	

Clogging

Push Rods, No. ND (solid design)
Oil Ring, % 0
Oil Screen, % 0

Observations, Comments

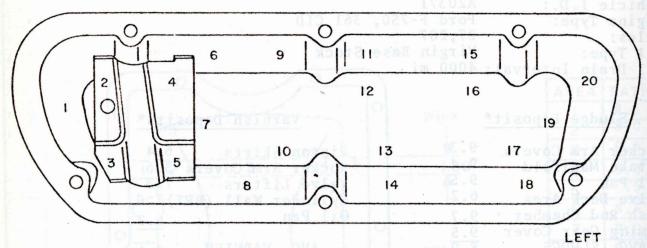
Virtually no rust on lifters despite use of leaded gasoline. Some dished valve lifters. V. slight corrosion on some compression rings.

Date: 5-78

Rater: E.R. Lyons

* 10=Clean

Rating Work Sheet No. I SLUDGE RATING OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH				_6_						SI	TE	TQ C	in	100	Th	αb		ħЬ	X		TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN						1	CS.			三位		1	O.A.				U O			719	Li ter	. \$ \$1.51 5 \$ 600 6 3	
1/44		1		C/e)		eb	8	og:	Œ	97	B			х			0				1881	5	.01
1/2A		, 6	Q	TH	x	tis	х	x	a	ov.	[8]		XS	nt			x	x	х	х	7	35	.18
3/4A			-		1	W.		o q	K.L.	9.4	6.0		25	3 31				- \\	pe			17	
AX	x	х	x	X		x			x	х	x	X.	x		х	x					12	60	.60
AB			1		S)		14	-	-5		6		7		92				0	3"		19.	
В						-4								-					P				
вс															1	da	LIE S	Ь	id	301	GW .	Morabe	H neu
С								6			1										0	7007	12 fil
D																							
E				V														- 4					
F																							
G																							
Н										5.1	TO		n'	5	TO	4 1	are.	3.2	n				
1			1																				
9	MO	2		hi	10	gas	6	eb	B O I	10	0	156	9	JE	G	RAN	in	TOT	ΔΙ	810	20	100	.79

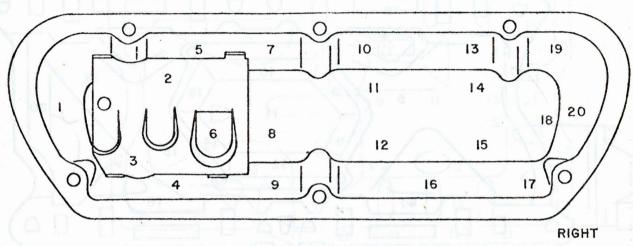
Inspector ERL

Sludge Merit Rating 9.2

Date _____5-78

Rater: E.R. Lyons

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

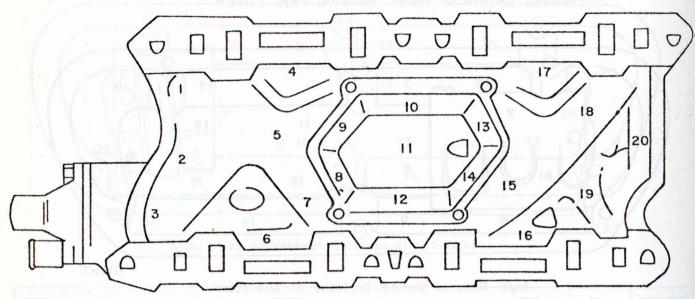
DEPTH					8 1 2					SI	TE										TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN																							THE STATE
1/44			XT.			x	x			x	x		x				x		x		7	35	.09
1/2A	x	x			x			х	x			x		x	x			x		х	10	50	.25
3/4A																							APAC
Α			х	x												х				1-1	3	15	.15
8A	+				1																4	1	HA
В						- MT																	1: 8
вс	\pm																					FEF	h ae
С	T																						1-19-
D																							11-10-
Ε																			Ī	-6-		THE F	7
F																						11-1-1	
G																	7						
Н				1															F				1
			9										-	T				T			-44-	TELET	
0.0.		0.0		ER				1.0	7.55	0	L.	1			GI	RAN	ID .	TOT	AL	1	20	100	.49 9.5

Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.5}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right}}{2} = \frac{9.3}{2}$

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

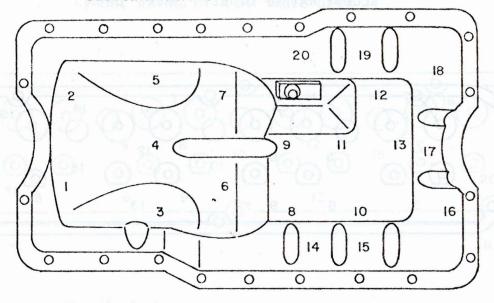


DEPTH			10		M	1				SI	TE					33	2				TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN																							NATE OF
1/4A	x	x	x	x	x	x		Ž		x	x			2			JŁ.	X		. N.	8	40	.10
1/2A					0.7		X.	x	x			x	x		X			X	X.		4	20	.10
3/4A																						160	- KIRNE
Α					-3-		х				- X			x	x	x	x	x	x	x	8	40	.40
AB																					300		BA
8													6										8
ВС																	-2-			_ '			
С																							
D																							u u
E																	1						
F				A.																			
G					-																		0
Н																				-			L A
															9		2	191	P.E.			ENATI	PETE
Ins	0.00	tor	Е	RL	0.5			.17	TO	T Q	MA	GR			G	RAN	4D	TO	TAL	pdg	20	100	.60

Date 5-78

Sludge Merit Rating 9.4

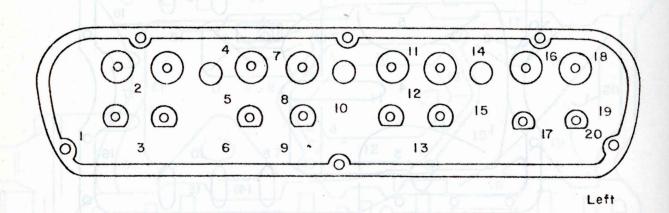
Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN



DEPTH			100.00							SI	TE										TOTAL	%	VOLUX
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	88					88	di	BH.		9		4-1		Sir	1	61		-6		-8-	3-10-15	3 11	IND)
1/4A	х	x				х	х														4	20	.05
1/2A			x	х	x			х	x	x	х	х	х	x	x	x	x	x	x	х	16	80	.40
3/4A								3		×				-/-	X	X			-30	X	-7×-12		311
Α																							3/4
AB																							Á
В					-																		64
ВС				+1									X										
С																							38-
D																	24-7						2
E																							
F																							3
G																							
н																							0
												,					1						
			E												G	RAN	ID	TOT	AL		20	100	.45

Date _____5-78

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



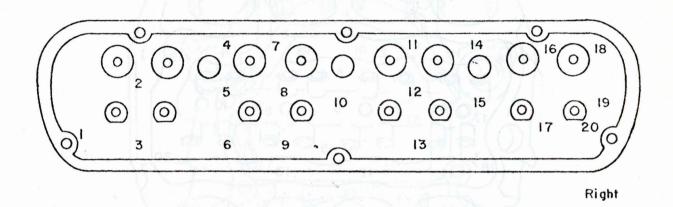
DEPTH	913	VICKO	EX	Dak		0.5	64	81	1	SI	TE	4	81	Site		0	-9-	-8-	-5-	di	TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN																							
1/44	17		IA																		z z II.	Re L	C [17]
1/2A		x	x	х	X	х	x	x	х	х	X	х		X	X	х	х	х			17	85	.42
3/4A									J														A
Α	x																36.	12			1	5	. 05
AB						- 14											1				1		8-1
В													x	4							1	5	,10
вс																							0
С																				х	1	5	.05
D																							
E					7.																		
F				1			T																
G							T																
н																T							
	1	nt.		95	H		T										i		1				1.1
. 8	160	g ·	ALZ!	M a	nhe	12	•	•		*			-		G	RAN	ND.	TO	TAI			Z V V	.77

Inspector ERL

5-78

Sludge Merit Rating 9.2

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



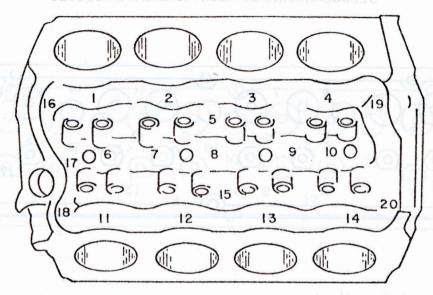
LEAD PAINT "C" DEPth AREA-1

DEPTH		a\c		_14	101					SI	TE					166					TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAH								1 1															HAT IS
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Inspec	tor ERL	
шэрсс		
Date -	5-78	-

Sludge Merit Rating $\frac{3.5}{2}$ Avg. Sludge Merit Rating $\frac{\text{Left+Right 6.2}}{2}$

Roting Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER



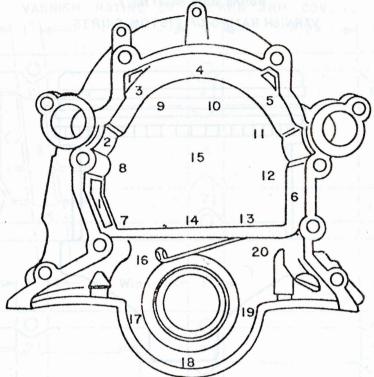
Note: Sites on Vertical Surfaces at Mid-Point

DEPTH		170		T.J.F	TO					SI	TE										TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN		v																					
1/4A	x	x	х	x	x	x	x	x	x	х	x	x	x	x	x	x	x	x	x	х	20	100	.25
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Inspector	ERL
Date	5-78

Sludge Merit Rating 9.7

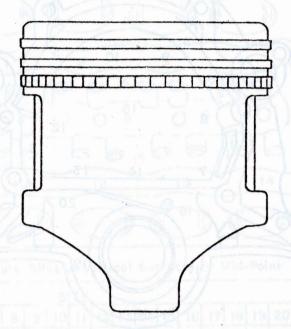
Rating Work Sheet No.6
SLUDGE RATING OF TIMING GEAR COVER



Note: Sites on Vertical Surfaces at Mid-Point

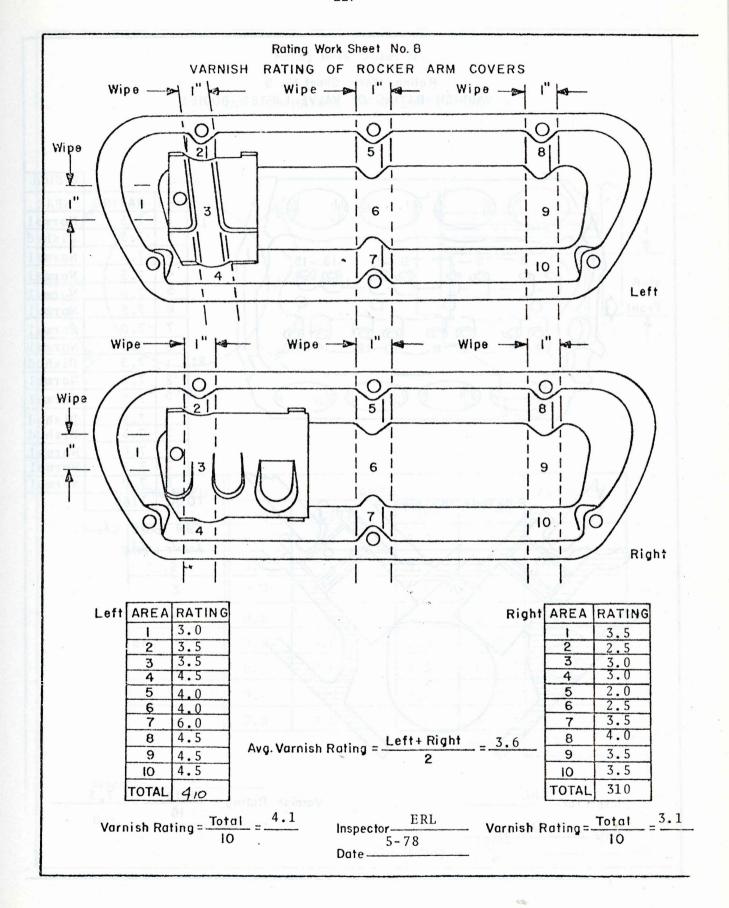
DEPTH	1) A	(F)	ĬÄ.		Ha	ATE	AVE			S	TE		1	116	118				OM.		TOTAL	%	VOLU
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вс								1000							lance and the								1/1
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In	spe	cto	E	RL	Si.				,				Tree -		G	RAN	ın	TOT	ΔΙ	L		51612	

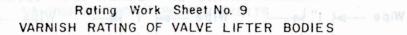
Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

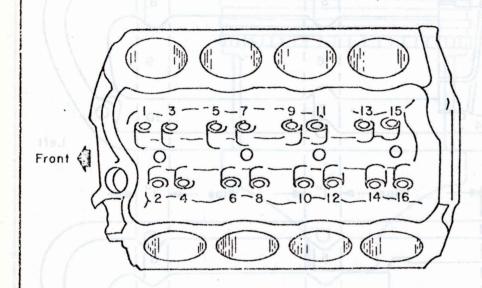


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS
Normal	Lt I	6,5	5,8	6.2	2-scratches
#1 1% corr. #2 < 1% corr.	2	6.4	6.0	6.2	Normal
Normal	3	6.5	6.0	6.3	Norma1
#1 CR 2% corr #2 CR < 1% corr.	4	7.0	6.8	6.9	1-scratch
#1 2% corr. #2 < 1% corr.	Rt 1	5.9	6.0	6.0	1-scratch
#2 1% corr.	2	6.6	6.4	6.5	Normal
Normal .	3	6.5	6.5	6.5	Normal Normal
Normal	4	6.3	6.3	6.3	1-scratch
	TOTAL	51.7	59.8		1 1 2
	AVERAGE	6.5	6.2		

Inspector	VARNISH RATING = AvgThrust + Avg Antithrust = 6.4
Date	Z Jali magagani

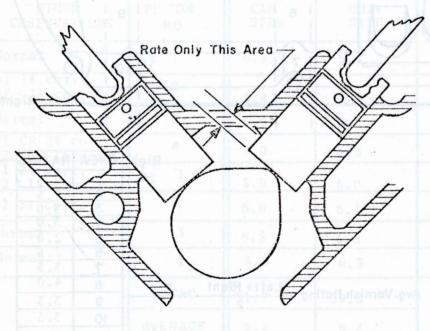






			VISUAL
		RATING	WEAR
Lt	1	7.5	Normal
1	2	7.5	Dished
	3	7.5	Normal
1.	4	7.5	Normal
	5	7.0	Normal
	6	7.5	Normal
	7	7.0	Normal
	8	7.0	Normal
Rt	1	7.3	Dished
	2	7.0	Normal
	3	7.0	Normal
	4	7.5	Dished
	5	7.5	Dished
	6	7.0	Normal
8	7	7.2	Normal
	8	7.0	Norma1
TO	TAL	1160	

CAM LOBES Show



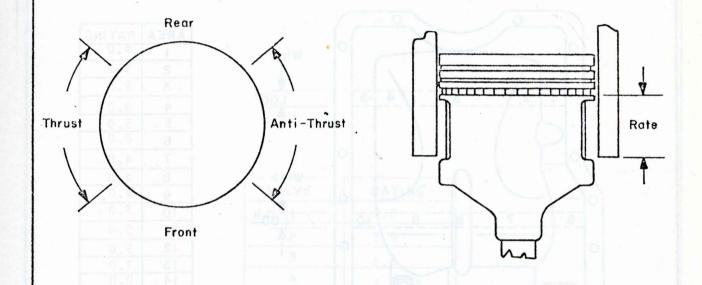
Inspector ERL

Date _____5-78

Varnish Rating = Total = 7,3

Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS

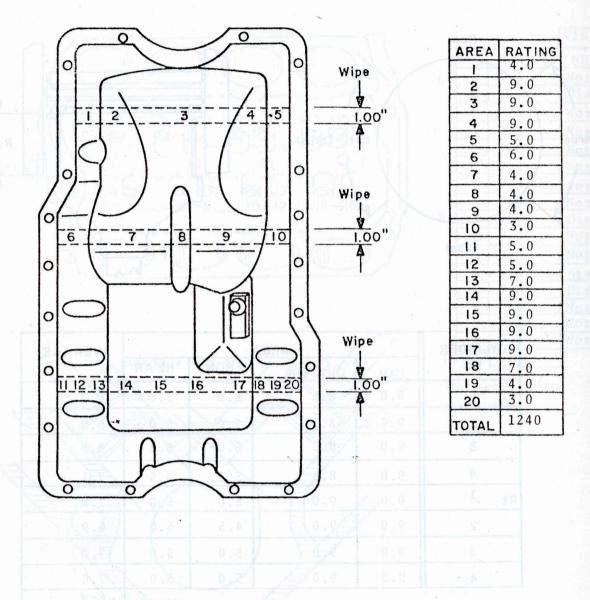


CYLINDER	5 9 0	ARE	Α		AVERAGE
NO.	CAM	OUTSIDE	FRONT	REAR	
Lt I	9.0	8.5	5.0	5.0	6.9
2	9.0	8.5	5.0	5.0	6.9
3	9.0	8.5	5.0	5.0	6.9
4	9.0	8.5	5:5	5.5	7.1
Rt 1	9.0	9.0	5.0	5.0	7.0
2	9.0	9.0	4.5	5.0	6.9
3	9.0	9.0	5.0	5.0	7.0
frap4 clos	9.0	9.0	5.0	5.0	7.0
Down	5-78			TOTAL	557

Inspector_	ERL	
Date	5-78	

Varnish Rating = $\frac{\text{Total}}{8} = \frac{7.0}{}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



Inspector ERL

Date ______

Varnish Rating =
$$\frac{\text{Total}}{20} = \frac{6.2}{}$$

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

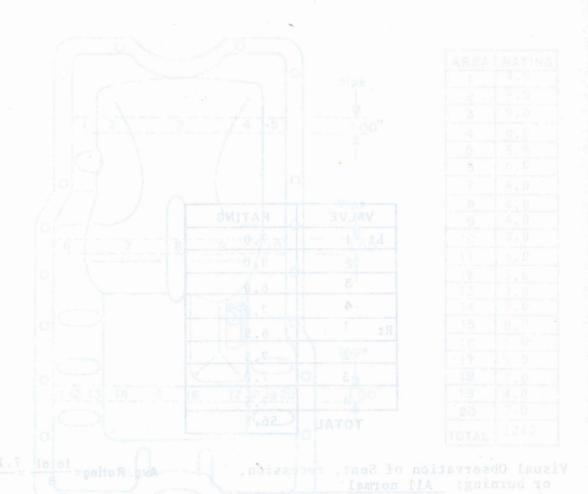
VALVE	RATING
Lt I	7.0
2	8.0
3	6.0
4	7.0
Rt 1	6.5
2	7.5
3	7.0
4	7.5
TOTAL	56.5

Visual Observation of Seat, recession, or burning: All normal

Avg. Rating= $\frac{\text{total}}{8} = \frac{7.1}{8}$

Inspector_	ERL	The many
Date	5-78	

Roting, Work, Sheet, Ng. 12



Date

ENGINE INSPECTION SUMMARY

Vehicle I.D.: A20369

Engine Type: Ford F-750, 361 CID

Miles: 31,576

Oil Type: MORCO Rerefined

Oil Drain Interval: 4000 mi

Sludge Deposit	*	Varnish Deposit	s*
Rocker Arm Covers	9.4	Piston Skirts	9.0
Intake Manifold	9.6	Rocker Arm Covers	5.3
Oil Pan	9.2	Valve Lifters	8.1
Valve Deck Area	9.4	Cylinder Wall (BRT)	9.5
Push Rod Chamber	9.7	Oil Pan	7.4
Timing Gear Cover	9.7		
AVG. SLUDGE	9.5	AVG. VARNISH	7.9

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max. 9.5	
Stuck Compression Rings	0	Piston Varnish, Min. 8.6	
Stuck Oil Rings	0	Intake Valve Deposits, Max. 8.0	
		Intake Valve Deposits, Min. 5.5	
		Intake Valve Deposits, Avg. 6.9	

Clogging

Push Rods, No. ND (solid design)
Oil Ring, % < 1
Oil Screen, % < 1

Observations, Comments

Virtually no rust on lifters, despite use of leaded gasoline. Some dished valve lifters. Very slight corrosion on 2 compression rings

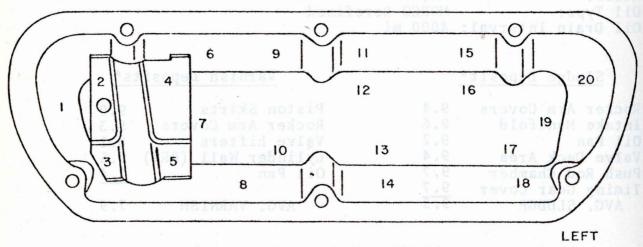
Date: 5-78

Rater: E.R. Lyons

* 10=Clean

ND = Not determined

Rating Work Sheet No. I SECTION STATES OF LEFT ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH	16					X.B.	d ,	Sh	III	S	TE	loj.	SI,	1		U O		,		ers	TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
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1/44	. 0	-	x		53	181	ogs	II L	х	B	х	х	x						х	х	7	35	.09
1/2A	x	x		x	x	x	x	х		x				x	x	x	х	x			13	65	. 32
3/4A	44																						
Α																-					5	urggor	
AB											1			(m	i	de	15	110	(s	αv	No.	Rods	(Eug)
В			4			-4														Ţ		Rings	1.50
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С									-														
D																							
E																							
F																							
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			•						40						G	RAN	an.	TO	TAI		20	100	.41

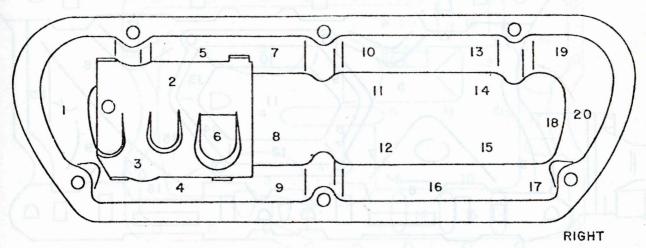
Inspector ERL

Sludge Merit Rating 9.6

Date ______5-78

later: 5-78

Rating Work Sheet No. Ia SLUDGE RATING OF RIGHT ROCKER ARM COVER



Note Sites on Vertical Surfaces at Mid-Point

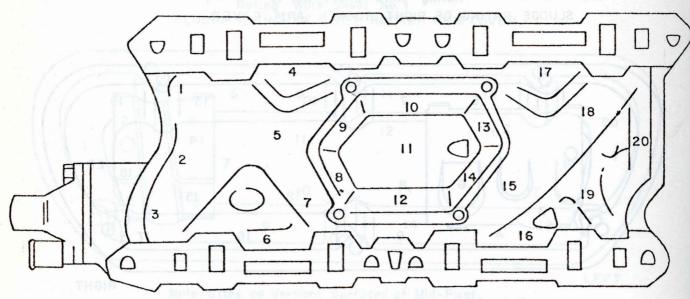
DEPTH		eV S								SI	TE	m				TIK					TOTAL	%	VOLUME
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTOR
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1/2A		- 57	x			х			х		X	х		x	х		x	х		х	10	50	.25
3/4A																							
Α		x		х	х		x	x		x		X. I	х			x			х		9	45	.45
A8	7 17																						
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Inspector ERL
Date 5-78

Sludge Merit Rating 9.3

Avg. Sludge Merit Rating= $\frac{\text{Left+Right}}{2} = \frac{9.4}{2}$

Rating Work Sheet No. 2
SLUDGE RATING OF UNDERSIDE OF INTAKE MANIFOLD

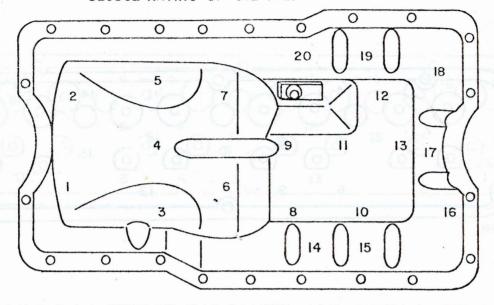


DEPTH	Įė.									SI	TE					TOTAL	%	VOLUM					
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN														TA.	15			Tal.	VG.			Superior Superior	
1/4A	x	x	х	X	х	х	х	X	х	х	х	х					х	х	х	х	16	80	.20
1/2A													х								1	5	.02
3/4A					J.d.				X														
Α	4													x	х						2	10	.10
AB																							
В																х					1	5	.10
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Date 5-78 SM spbulz

Sludge Merit Rating 9.6

Rating Work Sheet No. 3 SLUDGE RATING OF OIL PAN

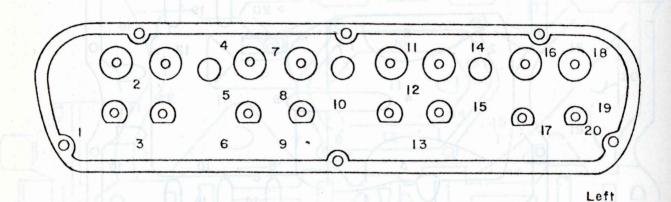


DEPTH		10								S	TE			N	1	112					TOTAL	%	VOLUX
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN								T				1		T	-								(ATTX)
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1/2A	x	x				x	x					х	x			x	x	x	х	х	11	5.5	.28
3/4A																							2444
Α		ia i	A CONTRACTOR	-				T				15									- Fx		
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В				x	-		T.	H						7		41			7		1	5	.10
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F														1									
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22		101						ATC							G	RAN	D.	TOT	ΔΙ				.67

Inspector ERL

Date 5-78

Rating Work Sheet No. 4 SLUDGE RATING OF LEFT VALVE DECK



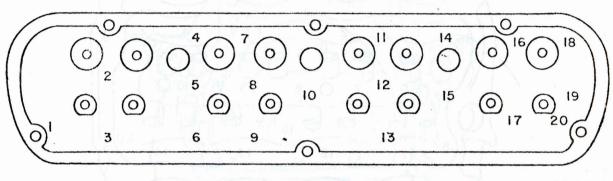
TOTAL % VOLUS DEPTH SITE CHECKS COVERED SCALE FACTO: 10 11 12 13 14 15 18 17 18 19 20 2 3 5 6 7 8 CLEAN 12 × X 60 .15 1/44 X XX X XX X 1/2A 3/4A A х X X X 8 40 .40 X X X AB B BC C D E G H 20 100 .55 GRAND TOTAL

Inspector ERL

Date ______

Sludge Merit Rating 9.4

Rating Work Sheet No.4a SLUDGE RATING OF RIGHT VALVE DECK



Right

DEPTH		TVO	فلم		win.				L	S	TE					A.			T	-	TOTAL	%	VOLUM: FACTOR
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	
CLEAN																						4-4-4	8303
1/4A		x	x	x	x	х	x	x		x	х	х		x	Х	х	Х	х	x		16	80	.20
1/2A																					Julea		
3/4A																				320			
Α					-				х				x							х	3	15	.15
AB	,									1-4	4												
В	x						-														1	- 5	.10
ВС												1				1			1	1			.10
С							-																
D																-	-	1-		ļ.,			
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								1		1	-	-		1						1	1.1		
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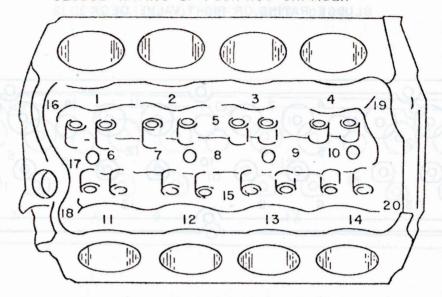
Inspector ERL

Date 5-78

Sludge Merit Rating 9.5

Avg. Sludge Merit Rating = Left+Right 9.4

Rating Work Sheet No.5 SLUDGE RATING OF PUSH ROD CHAMBER

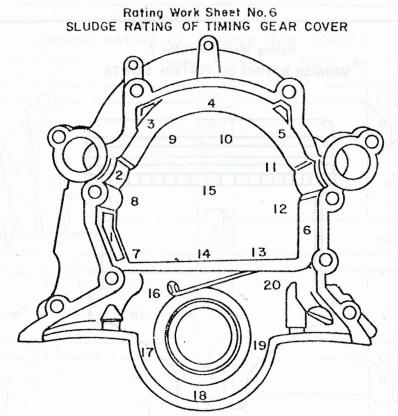


Note: Sites on Vertical Surfaces at Mid-Point

DEPTH								-		SI	TE									-	TOTAL	% S COVERED	VOLUME FACTOR
SCALE	do	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS		
CLEAN																							
1/4A	x	х	х	x	x	x	X	х	х		X	x	х	x	x	x	х	х	X	х	19	95	. 24
1/2A		1185		-																			
3/4A																							
Α										x											1	5	.05
AB				E																			
В																				H			
ВС						-									-								
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Inspector		ERL
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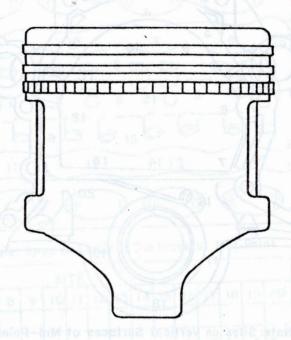
Sludge Merit Rating



Note: Sites on Vertical Surfaces at Mid-Point

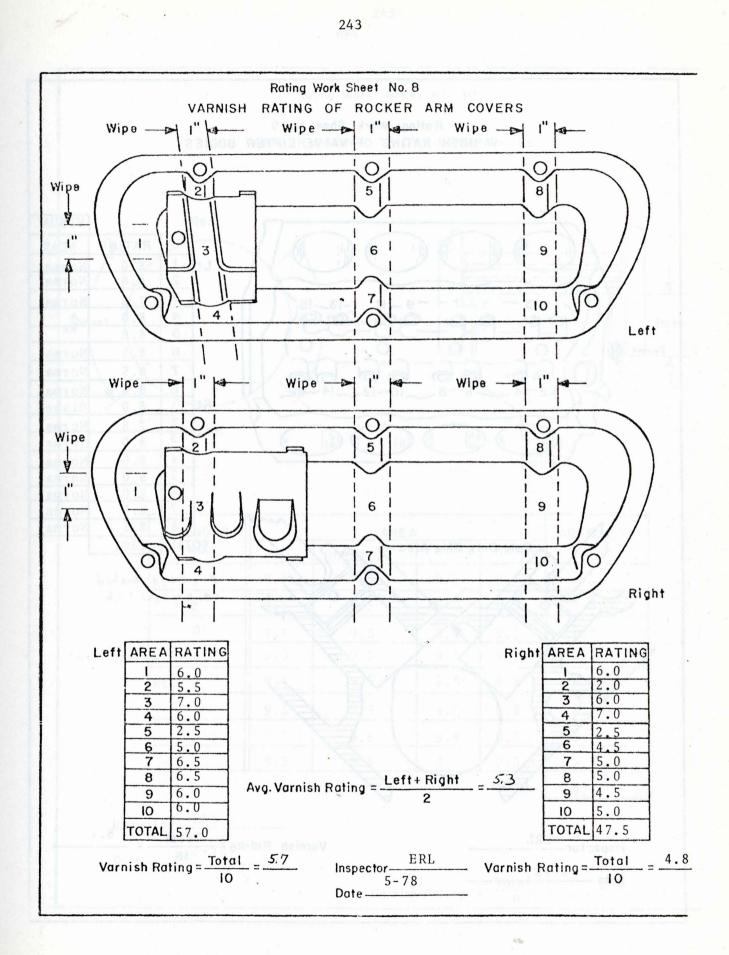
1	SITE 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 15 17 18 19 20															TOTAL	%	VOLU:				
	2	3	¢	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
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	ip &		spector_E	spector_ERL	spector_ERL	spector_ERL	spector_ERL	spector_ERL	spector_ERL	spector_ERL	spector_ERL	spector_ERL_	spector_ERL	spector_ERL	spector ERL G	Spector_ERL GRAN	spector_ERL GRAND	Spector_ERL GRAND TOT	Spector ERL GRAND TOTAL	Spector ERL GRAND TOTAL	Spector ERL GRAND TOTAL	Spector ERL GRAND TOTAL

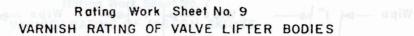
Rating Work Sheet No. 7
VARNISH RATING OF PISTON SKIRTS

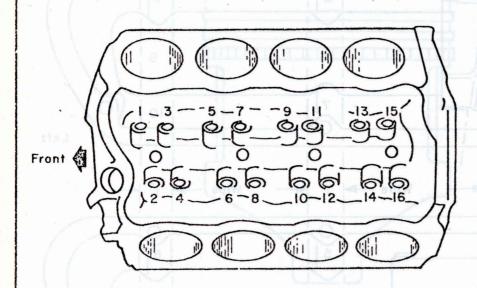


OTHER OBSERVATIONS	PISTON NO.	CAM SIDE	OUT- SIDE	AVERAGE	CON. ROD BRGS APPEARANCE		
OK	Lt	8.8	8.5	8.7	Normal		
#1,2 CR < 1%corr	2	8.6	9.2	8.9	Normal		
ОК	* 3	8.8	9.0	8.9	Normal		
ОК	4	9.0	9.5	9.3	Normal		
OK	Rt 1	9.5	9.0	9.3	Normal		
ОК	2	9.5	8.8	9.2	Normal		
OK .	3	9.4	8.8	9.1	Normal		
ОК	4	9.0	9.0	9.0	Normal		
	TOTAL	72.6	71.8				
	AVERAGE	9.1	9.0				

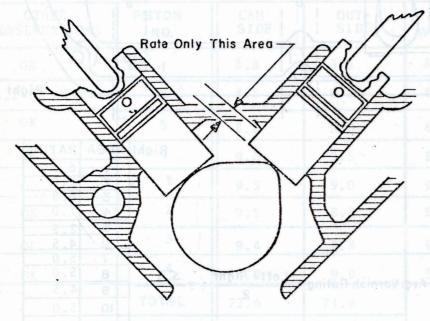
Inspector	VACAUGU BATING AvgThrust + Avg Antithrust 9.0
Date	VARNISH RATING = 2







			VISUAL
= [0	RATING	WEAR
Lt	1	8.0	Normal
	2	8.0	Normal
	3	7.8	Normal
1	4	8.0	*
	5	8.0	**
	6	8.5	Normal
	7	8.5	Normal
	8	8.5	Normal
Rt	1	8.0	Dished
	2	7.8	Normal
	3	8.0	Normal
	4	8.0	Normal
	5	8.0	Normal
	6	8.0	Normal_
	7	8.5	Normal
4	8	8.5	Normal
TO	TAL	1301	

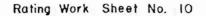


* 1. P.+ & Dished ** very light Dish

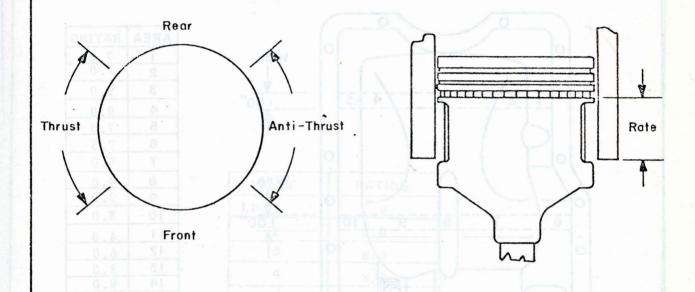
Inspector ERL

Date ______5-78

Varnish Rating = Total = 8.1



VARNISH RATING OF CYLINDER WALLS



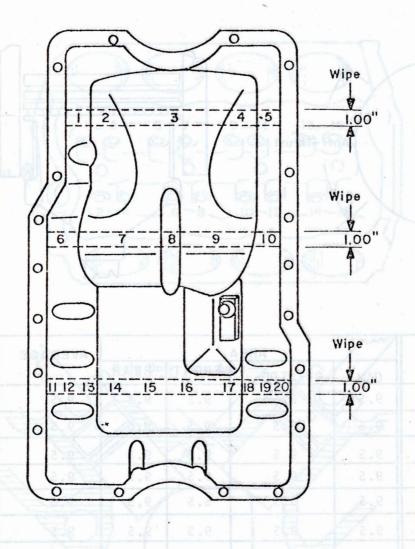
	CYLINDER	300	AREA			AVERAGE
	NO.	CAM	OUTSIDE	FRONT	REAR	
	Lt osl	9.5	9.5	9.5	9.5	9.5
	1AT 2	9.5	9.5	9.5	9.5	9.5
	bser3 tion	9.5	9.5	9.5	9.5	9.5
STOPE MARK	> 4	9.5	9.5	9.5	9.5	9.5
	Rt 1	9.5	9.5	8.5	9.5	9.3
	2	9.5	9.5	9.5	9.5	9.5
	3	9.5	9.5	9.5	9.5	9.5
	4	9.5	9.5	9.5	9.5	9.5
	Date	13-78			TOTAL	9.5

Inspector ERL

5-78

Varnish Rating = $\frac{\text{Total}}{8} = \frac{9.5}{}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
2	7.0
3	9.0
4	9.0
5	7.0
6	7.5
7	9.0
8	9.0
9	9.0
10	8.0
11	4.0
12	6.0
13	8.0
14	9.0
15	9.0
16	9.0
17	8.0
18	4.0
19	4.0
20	4.0
TOTAL	1475

Inspector ERL

Data ______

Rating Work Sheet No.12

INTAKE VALVE DEPOSITS

VALVE RATING Lt I 7.0 6.0 2 3 8.0 8.0 Rt 8.0 5.5 2 3 6.0 4 ! 6.5 TOTAL 550

Visual Observation of Seat, recession, or burning: ______ALL OK

Avg. Rating= $\frac{\text{total}}{8} = \frac{6.9}{}$

Inspector ERL

Date 5-78

	sion,		

ENGINE INSPECTION SUMMARY

Vehicle I.D.: A 18716

Dodge, 225 CID Engine Type:

63,910 Miles:

Virgin Base Stock Oil Type:

Oil Drain Interval: 10,000 mi

Sludge Deposit* Varnish Deposits* 8.3 Rocker Arm Covers Piston Skirts 5.7 Intake Manifold NA Rocker Arm Covers 4.8 9.1 Oil Pan Valve Lifters 7.6 9.7 Cylinder Wall (BRT) Valve Deck Area 5.1 NA Push Rod Chamber Oil Pan 5.1 8.6 Timing Gear Cover 8.9 5.7

Additional Ratings*

AVG. VARNISH

Stuck Valve Lifters	0	Piston Varnish, Max.	6.2
Stuck Compression Rings	0	Piston Varnish, Min.	5.0
Stuck Oil Rings	0	Intake Valve Deposits,	Max. 8.0
		Intake Valve Deposits,	Min. 6.0
		Intake Valve Deposits,	

Clogging

AVG. SLUDGE

Push Rods, No. NA (Solid Design) Oil Ring, % Oil Screen, %

Observations, Comments

Light to medium scuffing, left side all pistons v.v. slight corrosion on 2 compression rings

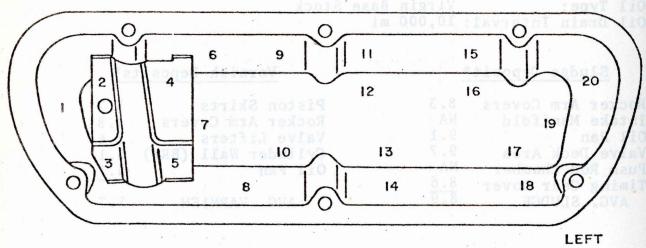
5-78 Date:

Rater: E.R. Lyons

* 10=Clean

NA = Not applicable

Rating Work Sheet No. I
SLUDGE RATING OF ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

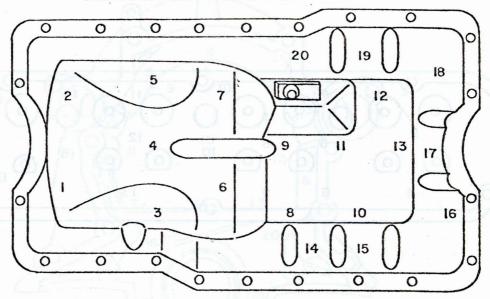
DEPTH	2	() ()				ail	4	da	Em	S	TE	ot	215	Ĺ		Ü.	131	20	a i	7 0	TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	0.	0 4	T.I.		80	18	e egr	u a	ev	.8		2/8	30							'nρ,			
1/44	64		5.7				, Alb			N 691.	х		2 45						16		1	5	.01
1/2A				х		x			X												3	15	.08
3/4A							<i>5</i> 7,				0	T								W		ninnof	
Α		x			х			х				х		х	х	х		х	Х	х	10	50	.50
AB								-1	N	ki set in	Yes	*			T(B	îz	ed-	bt	10		W. ON	Rods	1eu l
В		1,4	х			-17				х			х				х				4	20	.40
ВС																					7 (1)		
С	х						х														2	10.	.40
D								177	1 1	10.0	7.44		e e vo			10-7-7	uor	A PA	10	100			
E										= 17						-		-17	44				
F									2 1	er eile	9.170.6	0.	. 5	to.	4.8	një nje	321	ró	1				
G				h.																			
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1																		9					
															G	RAN	יוו	TOT	AL		20		1.39

Inspector ERL

Sludge Merit Rating — 8.

Date 5-78

Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN



DEPTH	30		1.5	Mol						S	ITE			1							TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	
CLEAN							9.1			74		ai l							nf I			I less	or area.
1/4A	Ü	Y					22						х		7			χ			1	5	.01
1/2A	2	3	13			7		9			111	x	14					x	х	х	4	20	.10
3/4A																						111.0	N.E.
Α	x	х	х	X	х	x	x	x	x	x	х			x	х	х	x				15	75	. 75
AB																							
В					•																		
ВС		1																					i A
С																							
D									Total Services														
Ε																					T I		
F											Ť												
G																							
н																							
1																					1 0		
					1	ATT-1									G	DAN	D .	TOT	14				.86

Inspector ERL

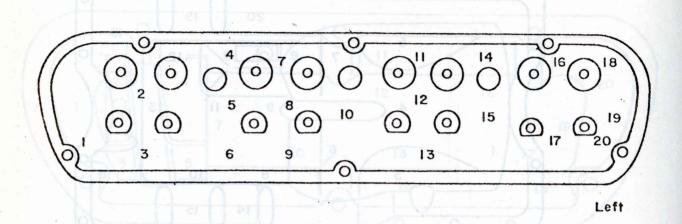
Date 5-78

Sludge Merit Rating -

Rating Work Sheet No. 4

SLUDGE RATING OF

VALVE DECK

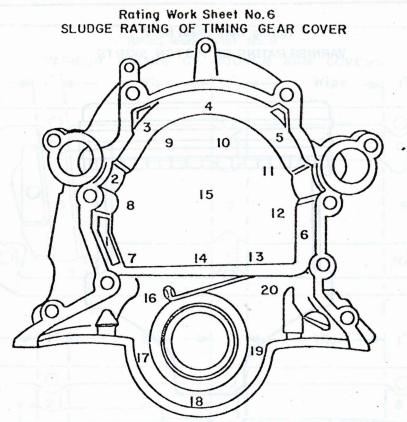


DEPTH	100		1	Mig			aley mark			SI	TE		· Mary	أوسا							TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	=	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN		7		4		U			05	10	1	4	1	19		1/4		19	1	20		HE IKE	
1/4A	х	X	х	х	х	x	x	х	х	x	х	х	х	х	Х	x	х	х	x	х	20	100	.25
1/2A	-0							See a		n Pasad la		nie nazyle		K.								A	
3/4A				X		4			E													15 6	
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С																							
D	3						X	-														10	
E																	le junta ju						
F	7																						
G																							
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Inspector ERL

9.7 Sludge Merit Rating

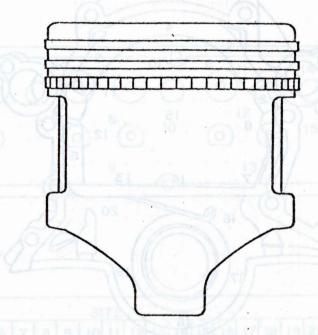
5-78 Date



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH	J.	A.	di A	Ä.		90	9.113	IVA	1	S	ITE	171		15	Ť	Later	. 1			3.14	TOTAL	%	VOLUN
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN																						7198) 7	
1/4A		1	m	334			Ŧ							É		2					1 (9.5)	Health	ima)
1/2A														1	Ĵ						17 7	2013	e il
3/4A												-								\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		13.00	e dJ
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В	х	х	x	х			10				S. i				8.	2 .					4	20	.40
ВС				3.			·																
С		F																	-				
D				4			-												orion in				
E					-						\$, 1	8			à,	ĒĒ			,1,1	TOT			
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	ate			78											J					luda	e Merit R		8.6

Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

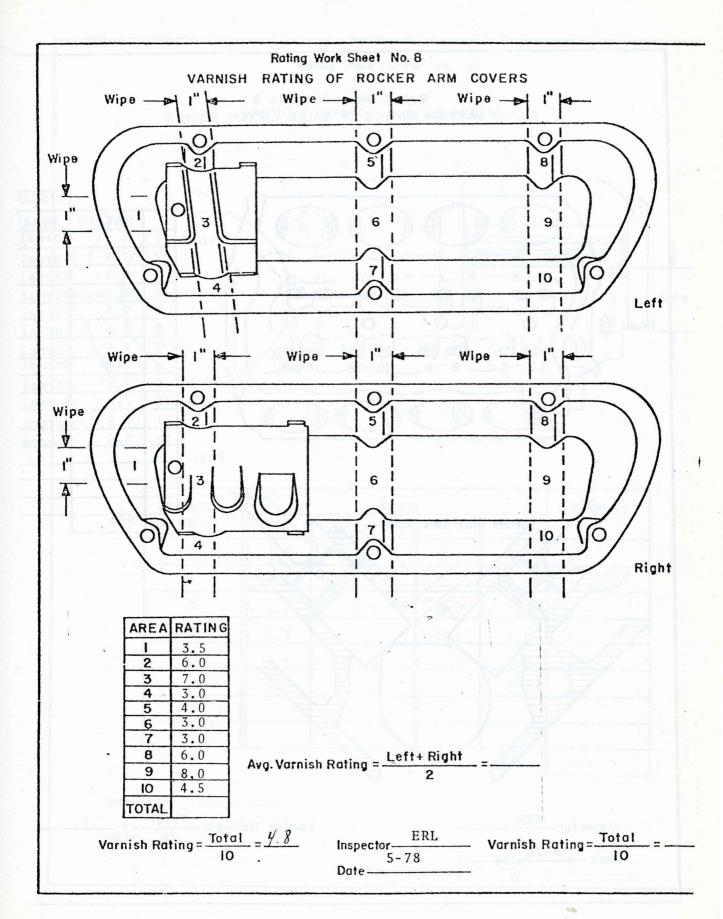


OTHER OBSERVATIONS	PISTON NO.	LEFT	RIGHT	AVERAGE	CON. ROD BRGS APPEARANCE
#2CR 1% corr, Lt scuff (left)	O bs el lax	5.0	6.0	6.0	Normal
#2Ck 1% corr-Lt scuff left side	2	5.4	6.2	5.8	Normal Normal
Lt scuff left side	† 3	5.2	5,6	5.4	Normal
Lt scuff left side	4	5.0	5.6	5.3	Normal
Med scuff left side	5	5.2	5.6	5.4	Normal
Lt scuff left side	6	5.8	6.2	6.0	Normal
	TOTAL	32.6	35.2		
	AVERAGE	5.4	5.9		

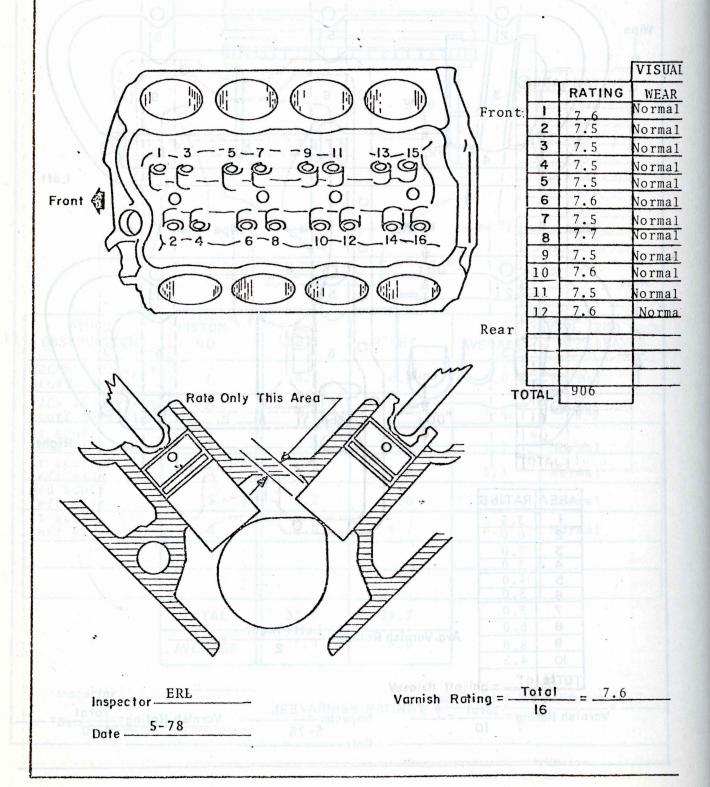
Inspector ______ VARNISH RATING = AvgThrust + Avg Antithrust _ 5.7

Studge Medt Pating

Date ___

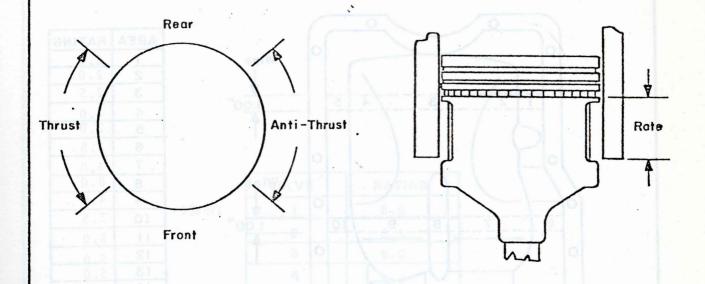


Rating Work Sheet No. 9 VARNISH RATING OF VALVE LIFTER BODIES



Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



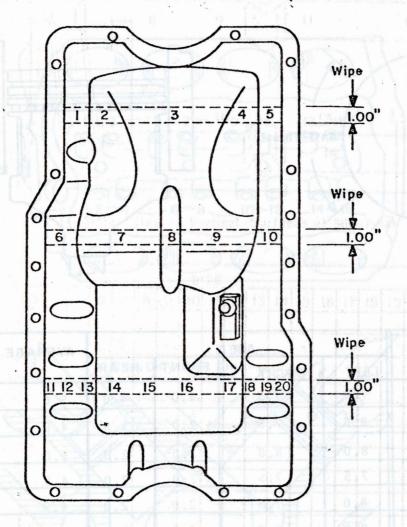
CYLINDER	p.q.lVi	AREA			AVERAGE
NO.	LEFT	RIGHT	FRONT	REAR	
er.	7.0	7.5	4.0	4.0	5.6
2	8.0	7,5	2.0	2.0	4.9
3	8.0	8.0	2.0	2.0	5.0
4	7.5	7.5	2.0	2.0	4.8
5	8.0	7,5	2,0	2,0	4,9
6]]	8.0	8,0	2.5	2.5	5.3
laspaci ir.	37414				
Gate	5-78			TOTAL	305

Inspector __ERL

Date _____

Varnish Rating = $\frac{\text{Total}}{8} = \frac{5.1}{100}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
	2.0
2	2.0
3	2.0 2.0 2.5
4	
4 5	2.0
6	2.5
7	3.0. 6.0
8	6.0
9	4.0
10	2.5
11	5.0
12	5.0
13	5.0
14	9.0
15	9.0
16	9.0
17	
18	9.0
19	8.5
20	4.0
TOTAL	1025

Inspector___ERL

Varnish Rating = Total = 5.1

Rating Work Sheet No.12

INTAKE VALVE DEPOSITS

AVG. VARWISH

FRONT

locker Arm Covers

VALVE	RATING
ádi Hanal	8.0
2	6.5
3 7	6.0
4	6.0
5 11	6.0
6	6.5
/	
V	
TOTAL	390

REAR

Visual Observation of Seat, recession, or burning; ALL OK

Avg. Rating= $\frac{\text{total}}{8} = \frac{6.5}{}$

Inspector ERL

Date 5-78

Roling Work Sheet No.12 11 off feeds wrow equipmed the Month of Windshelp Control of the Control

	Dourted II		
	0 84		15 9.6
	ession.	ation of Scat, rece	or burning:

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A18710

Engine Type:

Dodge 225 CID

Miles:

25,617

Oil Type:

MORCO Rerefined

Oil Drain Interval:

10,000 mi.

Sludge Deposit*

Varnish Deposits*

	-		A 17
Rocker Arm Covers Intake Manifold Oil Pan	9.5 NA 9.7	Piston Skirts Rocker Arm Covers Valve Lifters	9.0 7.0 9.5
Valve Deck Area	9.7	Cylinder Wall (BRT)	9.1
Push Rod Chamber	NA	Oil Pan	7.6
Timing Gear Cover	9.3		
AVG. SLUDGE	9.6	AVG. VARNISH	8.4

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max.	9.8
Stuck Compression Rings	0	Piston Varnish, Min.	7.9
Stuck Oil Rings	0	Intake Valve Deposits, Max.	9.0
OTDAY TORRESTON PROPERTY INC. IN CHAIN		Intake Valve Deposits, Min.	6.0
		Intake Valve Deposits, Avg.	7.7

Clogging

Push Rods, No. NA (solid design)
Oil Ring, % < 1
Oil Screen, % < 1

Observations, Comments

Light to medium scuffing all pistons, left side Several compression rings with very slight corrosion

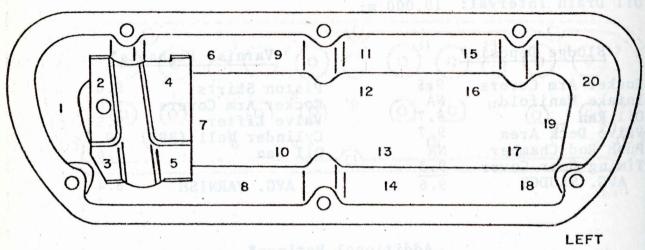
Date: 5-78

Rater: E.R. Lyons

* 10=Clean

NA = Not Applicable

Rating Work Sheet No. I
SLUDGE RATING OF ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH			vel	ننه	4	100	n a		au	SI	TE	1	10		101	0				100	TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	1	4	2.V.		83	SI	2.9	II.	θV	ĻS	. 5	70					ji Length	i k	À				
1/44				х		х	х		х		Х	х			х		de l'		A		7	35	.09
1/2A			х		х			x					х	х		X	ered.	x	100	x	8	40	.20
3/4A															all the same of	Territori Min	Aught is a	es din			one of the provide		
Α	X	X								х				(I	g I	39	х	iΓ	х	All	5 ON	25	.25
AB											*									1		181117	The same
В						- 18															List Manager		
вс																							and and
С																							Desi.
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E		1																10					
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G 1							9	bΪ		de		2.0		210	1	LB	81	1.1	UUS	18	medim	03 3113	
Н					2.1	o in a	U/A	3.0		H8							0						
																13	St. A.	10	10	AL			
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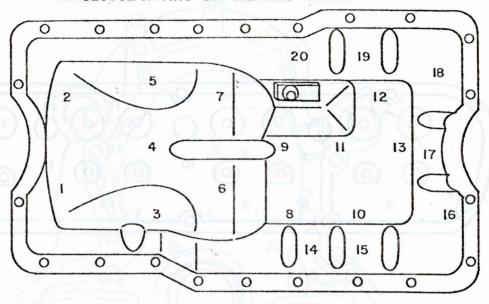
Inspector ERL

Date 5-78

Not Applicable

Sludge Merit Rating -

Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN

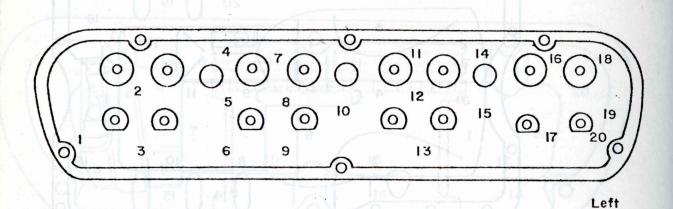


DEPTH		_								Si	TE			L							TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACT
CLEAN		sysCl 3			S				H	211					H	9	8		8	3	- E S	1 3 200	1
1/4A		х		х	х		х	х	х	х	х	х	х					х	х	х	13	65	.16
1/2A	х	20070	x		X	x	2			X.	X		X	х	x	x	х		2-1		7	35	.18
3/4A	1	-	3																			1 1.81	
Α		-0.021										aketo											
AB					-2														15.				
В																			120		11		1
вс			- China		otalian (c					at state of	alian (-10	
С		-					-3		X	X				7. 1									
D			-																				
E																							
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G		James		cn								palin)											
н	wra:																						
1	25-10		Smither	en isa					estate a													LIN	
		and the													G	RAN	4D	TOT	AL		20	100	.34
	In	spe	ctor		ERI	IA	gr								J						dge Mer	it Rating	9.7

5-78

Roting Work Sheet No. 4

SLUDGE RATING OF WALVE DECK

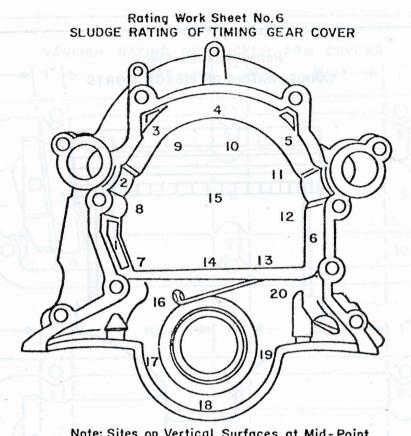


	E.K.	John .	21	2c	or l	AL.	VL	arl	S	TE	de la	21	Lily	1	0	by 1	0	3	a	TOTAL	%	VOLUE
1	2	3	4	5	6	7	8	9	10	=	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
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х	х	Х	х	х	x	х	х	х	х	х	х	х	х	X	x	x	х	x	x			.25
		X		7			W.											44				
			k											363								
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	all and													200	internit			te imistr	Oncertain			
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		n																rol.				
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Inspector___ERL

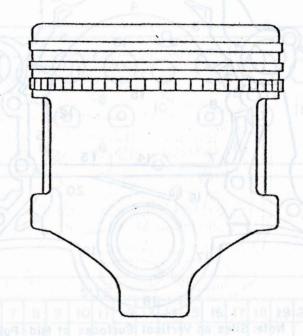
5-78 Date -

VALUE OF STATE OF STA Sludge Merit Rating $\frac{9.7}{}$



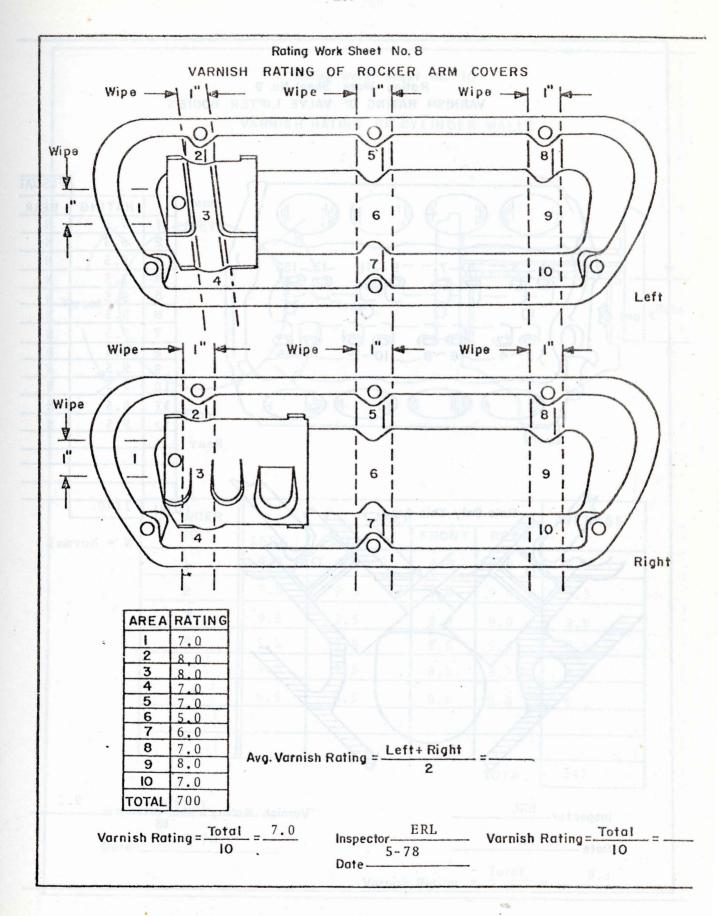
DEPTH	08		100					ii.	Á	SI	TE			75				(M	OTE	19	TOTAL	%	VOLUM
SCALE	1/	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN		2	1	ā	N		D	F			ALC:										10712	frauge.	rJ II.
1/4A		1.58	17.0			07%			-	0	ii.		х	x		х	x	х	x	x	7	35	.09
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н			Total					L									1				w.	T	
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- Ir	ispe	cto	r_I	RL	PA		257 1172	1 Ha		ЭM	ITA	用目	BH	AR	GI	RAN	ID '	TOT	AL		20		.74
D	ate		5-	78											J.	-				luda	e Merit R	ating	9.3

Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

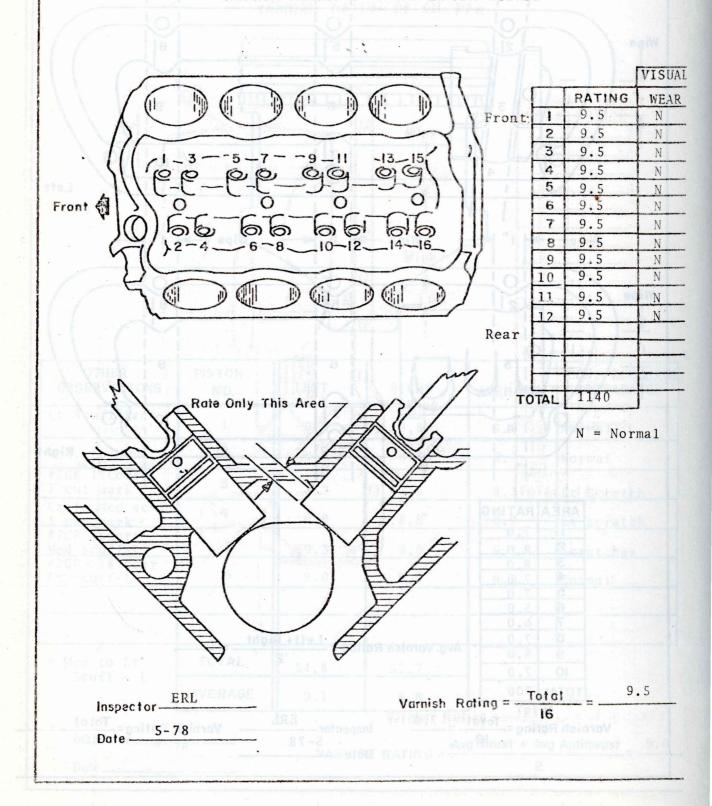


OTHER OBSERVATIONS	PISTON NO.	LEFT	RIGHT	AVERAGE	CON. ROD BRGS
Lt Scuff-Left		9.8	9.8	9.8	Norma1
Med. to Hvy Scuf	2	9.0	8.3	8.7	Normal Normal
#2CD 10C	3	8.7	7.9	8.3	Lt Scratch
Lt to Med scuff 1 cut mark	4	9.0	8.8	8.9	Lt scratch
#2CR 1%corr Med scuff-L	5	9.3	9.0	9.2	Scratches
#2CR < 1% corr Lt scuff-L	6	9.0	8.9	9.0	Normal
* Med to Lt Scuff - L	TOTAL	54.8	52.7		
Jedii L	AVERAGE	9.1	8.8		

Inspector ______ VARNISH RATING = AvgThrust + Avg Antithrust = 9.0

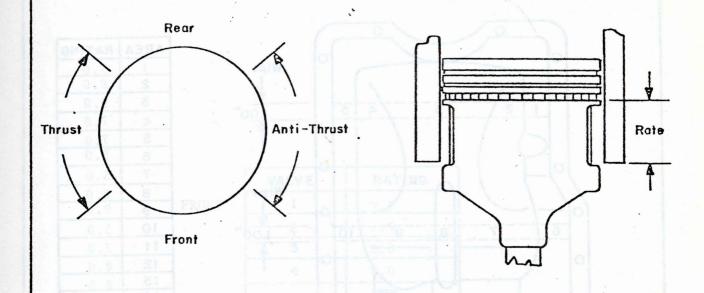


Rating Work Sheet No. 9 VARNISH RATING OF VALVE LIFTER BODIES



Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



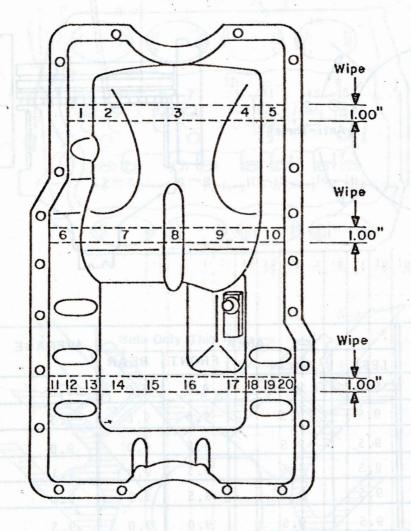
CYLINDER	eqily	ARE	Α		AVERAGE
NO.	LEFT	. RIGHT	FRONT	REAR	
E/ 1	9.5	9.5	8.0.	9.0	9.0
2	9.5	9.5	9.0	9.0	9.3
3	9.5	9.5	8.0	9.0	9.0
4	9.5	9.5	8.5	9.0	9.1
5 \	9.5	9.5	8.5	8.5	9.0
6]]	9.5	9.5	9.0	9.0	9.3
	ERL				
	4.78				
EXPLES COMMO				TOTAL	547

Inspector_	ERL	*	
mopoulor L	10.7		

Date _____

Varnish Rating = $\frac{\text{Total}}{8} = \frac{9.1}{8}$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
10/	7.0
2	7.0 8.0
3	9.0
4 5	7.0 7.0 5.0
5	7.0
6	5.0
6	5.0.
8	8.0 9.0
9	9.0
10	5.0
11	7.0
12	8.0
13	8.0
14	9.0
15	9.0
16	9.0 9.0 9.0
17 18	9.0
	8.0
19	7.0
20	7.0
TOTAL	1510

Inspector ERL

Varnish Rating = Total = 7.6

Dato 5-78

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

v v m	VALVE	RATING
FRONT	iditional i	9.0
275	2	7.5
s Rings	. 3	8.0
	4	8.0
	5 1	6.0
	6	7.5
REAR		
		-
Ligatia	TOTAL	460

Visual Observation of Seat, recession, or burning:

All ok

neleta Adam Covers

Avg. Rating= $\frac{\text{total}}{8} = \frac{7.7}{}$

Inspector _	ERL	101, 000
Date	5-78	piptona -

Rotting Work Sheet No.12

13 ON SWITCH VALVE DEPOSITS

PRONT PAINS PRONT					
VALVE RATING AND RATING VALVE RATING AND RATING VALVE RATING AND RATING AND RATING VALVE RATING AND RA					
FRONT SALVE RATING FRONT FRO					
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FRONT					
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REAR 900 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					
REAR 900 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					
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REAR STATE OF STATE O					
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Visual Observation of Seat, recession, Avg. Roting total = Z. Inspector ERL Date 5-78 Light spoint delirov Light spoint delirov Light spoint delirov Light spoint delirov					
Visual Observation of Seat, recession, Avg. Roting total = Z. Inspector ERL Date 5-78 Light spoint delirov Light spoint delirov Light spoint delirov Light spoint delirov					
Visual Cheervation of Seat, recession, Avg. Rotings total = 12 or burning: All ok Inspector ERL Date 5-78 Light applies delayor					
Wisual Observation of Seat, recession, Avg. Raings to a large of burning; All ok					
Visual Observation of Seat, recession, Avg. Rotings to a burning; All ok Inspector ERL Date 5-78 LEANT Total and Ashrov					
or burning; All ok Inspector ERL Date 5-78 LEGIT Total debries debries debries and debries and debries debries and debries					
Inspector ERL S-78 Later applies delivery deliv					
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Inspector ERL Date 5-78 LEGG Parish Reins delined					
Inspector ERL Date 5-78 LEGIT - Spring debrev					
Lingscion - ERL Vernish Ratings Total - 1.6					
Lingscion - ERL Vernish Ratings Total - 1.6					
Lingscoor ERL Versieh Reging 7 Teles					
Sold Starting File Rating Total a La					
Inspector ERL Veridek Rating = Total a 1.0					
Inspector ERL Versieh Raying - Total - 1.6					

ENGINE INSPECTION SUMMARY

Vehicle I.D.:

A18729

Engine Type:

Dodge 225 CID

Miles:

31,950

Oil Type:

Virgin Base Stock

Oil Drain Interval: 8.000 miles

Sludge Deposit* Varnish Deposits* Piston Skirts Rocker Arm Covers 9.2 6.1 5.0 NA Intake Manifold Rocker Arm Covers 9.2 Valve Lifters 8.9 Oil Pan 6.7 9.7 Cylinder Wall (BRT) Valve Deck Area NA 5.5 Oil Pan Push Rod Chamber 9.1 Timing Gear Cover 9.3

Additional Ratings*

AVG. VARNISH

6.4

Stuck Valve Lifters	0	Piston Varnish, Max. 6.5
Stuck Compression Rings	0	Piston Varnish, Min. 5.5
Stuck Oil Rings	0	Intake Valve Deposits, Max. 8.0
		Intake Valve Deposits, Min. 7.0
		Intake Valve Deposits, Avg. 7.4

Clogging

AVG. SLUDGE

Push Rods, No. NA (solid design) Oil Ring, % Oil Screen, % 0

Observations, Comments

Very light scuff on several pistons - left side

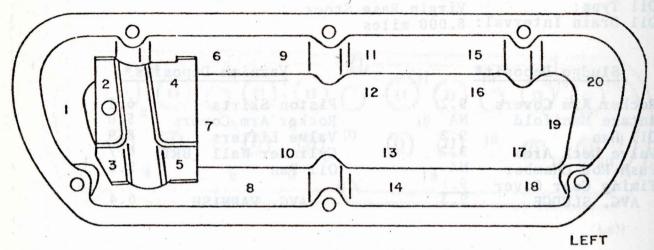
Date: 5 - 78

Rater: E.R. Lyons

* 10=Clean

NA = Not Applicable

Rating Work Sheet No. I
SLUDGE RATING OF ROCKER ARM COVER



Note: Sites on Vertical Surfaces at Mid-Point

DEPTH						л	M	Ìd	air	SI	TE	god	le i	q.		0		B	e ni	3	TOTAL	%	VOLUME FACTOR
SCALE	1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	
CLEAN	71.		12.1	No.	10	1	0.0	98	9	T.E	Vi.	SA.											
1/44			-												THE STATE OF	x	х		The ear		2	10	0.02
1/2A		1		X	x	х	х				x				х	1		x		х	8	40	.20
3/4A	Λ.																P		200.00			on in on	
Α		X						x	х	х		х	x	x	-	Section 2		159-4	x		8	40	.40
AB		4								and the same					(m		95	D.	10	4)		* 80 CX	0.542
В	x		x			-4								-		The second	1				2	10	.20
BC									1		The same of												
С										The second			Service Services			1							
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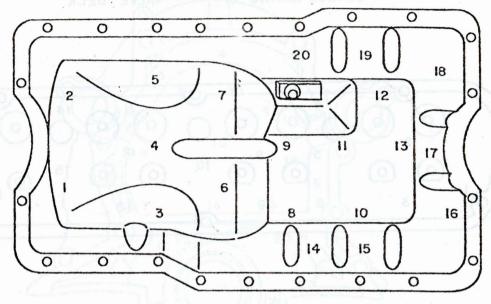
Inspector ERL

Sludge Merit Rating 9.2

Date ______5-78

10=Clenn

Rating Work Sheet No. 3 SLUDGE RATING OF OIL PAN



SCALE		SITE																			TOTAL	%	VOLU
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	17	18	19	20	CHECKS	COVERED	FACT
CLEAN	TV.		ЖŌ	HO	0				1 8	1, 14										0	1 A C		
1/4A																		х			1	5	.01
1/2A			10	x												x	x		X	х	5	25	. 1.2
3/4A																							
Α	x	х	х			x	х	х	х	х	x	х	x	x	х						14	70	.70
AB																			H				
В					٠		d												H				
ВС	-																						
С																		1					
D	c																						
E										(
F																							
G		-																					
Н		+			1						,												24
- 1																							II.
					I										G	RAN	4D	TOT	TAL		20	100	9.2

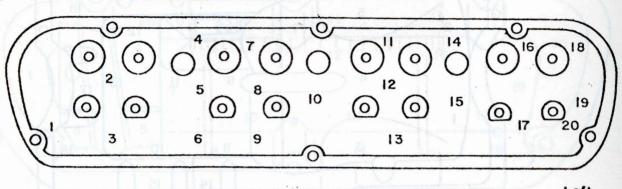
Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.2}{}$

Rating Work Sheet No. 4

SLUDGE RATING OF VALVE DECK

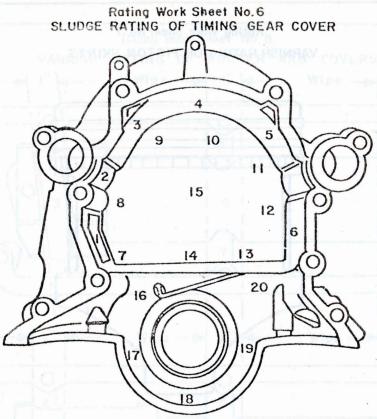


Left

SITE											148	TOTAL	%	VOLUM								
1 2	2 3	3 .	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
																						N-I-
x :	x x		x	x	x	х	x	х	х	х	х	x	x	x	x	х	x	x	х	20	100	.25
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ERL Inspector-

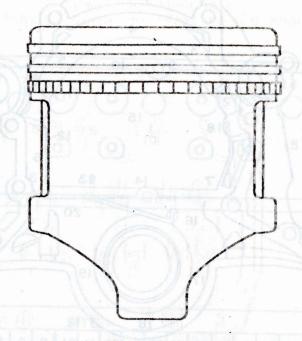
5-78 DateSludge Merit Rating-



Note: Sites on Vertical	Surfaces	at	Mid-Point
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DEPTH	(AS	N.	A	t.	BP	A Par	W#			SI	TE				134				MC		TOTAL	%	VOLUM FACTOR
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	
CLEAN		100	12	la la	- 4	7	07				yea	- Jan 191			M				8		t A - di	18306	
1/4A		eine	οŅ	K	1	17	Tu'				10			1	3				S		10.1	V Oxy	
1/2A	1	m't	οK			To	1.5				. 0		x			х	х	х	x	х	6	30	.15
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A	x	x	х	x	х	х	х	х	X	х	x	х		х	X	7	7	7			14	70	.70
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G						5.			A	- 6	. 0			- 18	3 .						1.0		
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1.10		110	27818	. 61		141		7 1 2	- 2). DAS	TAS	Н	ejin	PAN		1	RL					Total	
in	spe	cto	r_E	RL				10							G	DAA	ın .	TOT	·AI		20	100	. 85

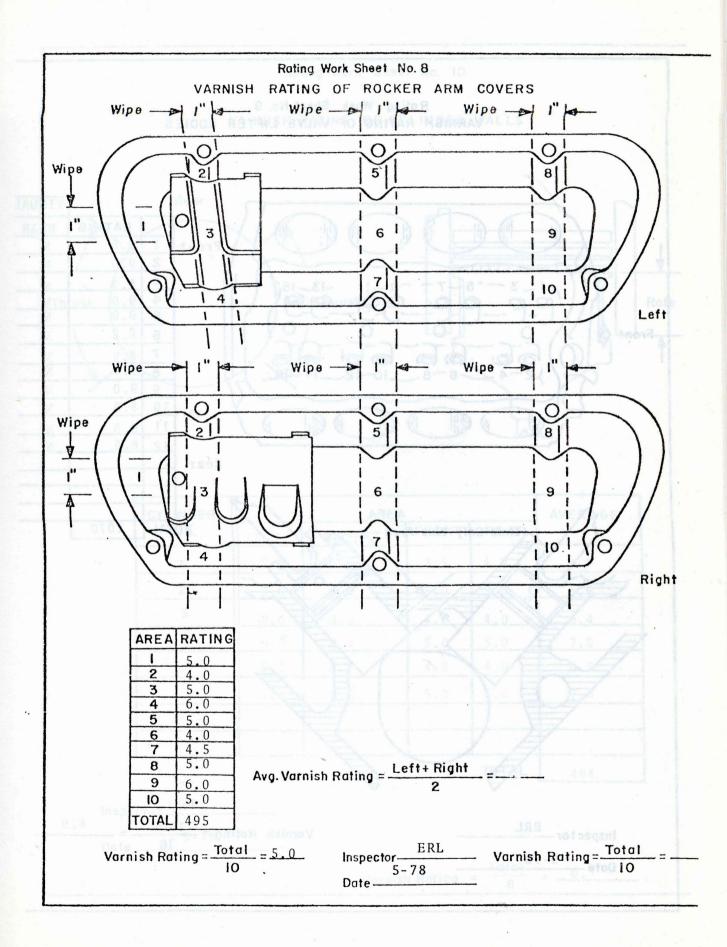
Rating Work Sheet No. 7
VARNISH RATING OF PISTON SKIRTS



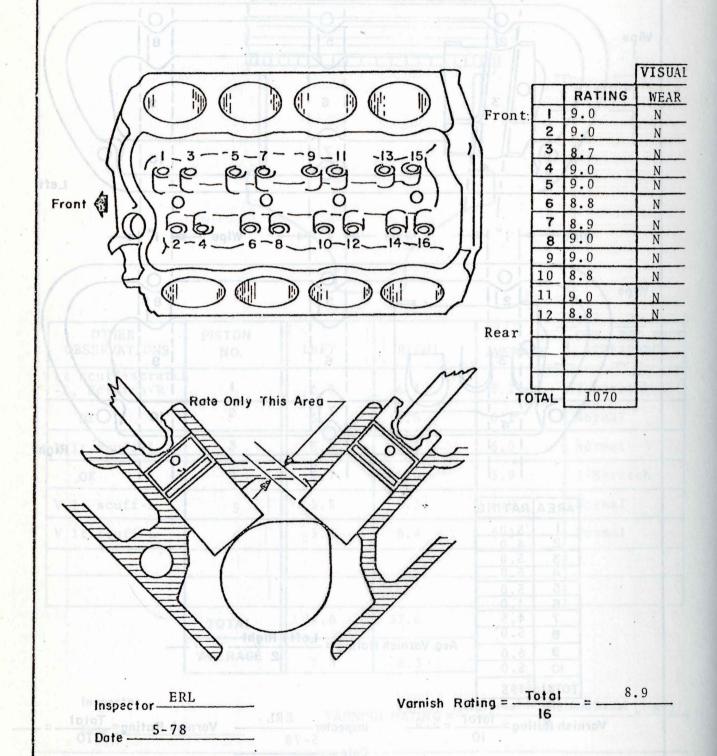
OTHER OBSERVATIONS	PISTON NO.	LEFT	RIGHT	AVERAGE	CON. ROD BRGS
Lt scuff+scratcl -L, Scratch-R	os el la sy	6.0	6.4	6.2	2-scratches
ОК	2	5.7	6.5	6.1	Normal
V lt scuff-L	* 3	5.9	6.0	6.0	Normal Normal
ОК	4	5.7	6.0 >	5.9	1-Scratch
V lt scuff-L	5	5.5	6.3	5.9	Normal
V lt scuff-L	6	5.8	6.4	6.1	Normal

	TOTAL	` 34.6	37.6		
	AVERAGE	5.8	6.3		

Inspector ______ VARNISH RATING = AvgThrust + Avg Antithrust _ 6.1

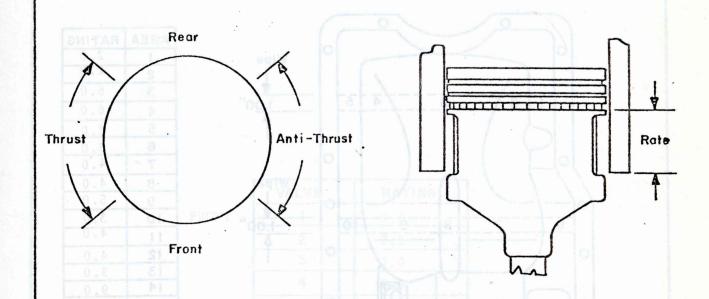


Rating Work Sheet No. 9 VARNISH RATING OF VALVE LIFTER BODIES



Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS

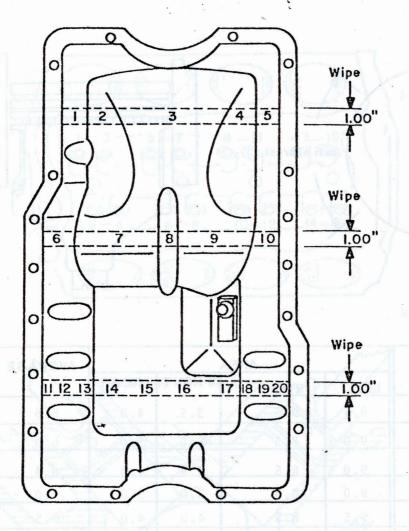


CYLINDER		AREA													
NO.	LEFT .	RIGHT	FRONT	REAR	ET SETH										
08	9.5	9.5	3.5.	4.0	6.6										
2	9.0	8.5	5.0	5.0	6.9										
Obse 3 vari	9.0	8.5	4.0	4.0	6.4										
4	9.0	9.0	5.0	5.0	7.0										
5	9.5	8.5	4.0	4.0	6.5										
6]]	9.5	8.5	5.0	5.0	7.0										
)	12.90 %														
	5 B 1 B 16														
D010				TOTAL	404										

Inspector_	ERL
Date	5-78

Varnish Rating =
$$\frac{\text{Total}}{8} = \frac{6.7}{}$$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
	2.0
2	The same of the sa
3	6.0
4	6.0
5	2.0
6	3.0
7	4.0 4.0 5.0
8	4.0
9	5.0
10	3.0
11	4.0
12	4.0
13	5.0 9.0
14	9.0
15	9.0
16	9.0
17	9.0
18	9.0
19	9.0
20	5.0
TOTAL	1090

Rating Work Sheet No. 12 INTAKE VALVE DEPOSITS

	VALVE	RATING		
FRONT	idi tipnal	7,5		
	2	7.5	e. Max.	3 .0
	0 3	7.0	L, Mib.	
i.	4	7.0	Deposits,	
21	5	7.5	Deposits.	
*	6	8.0		
REAR	1			
^ _		2	1	
A. (solid	TOTAL	445]	

Visual Observation of Seat, recession, or burning: ALL OK EXCEPT NO.5

EXH. VALUE Appeared to have very sight Leak

Avg. Rating= $\frac{\text{total}}{8} = \frac{7.4}{}$

Inspector _	ERL	DES LOUGEBLE
Date	5-78	on left side all p

Ruling Work Sheet No.12

	.O.X 5		
	of South recession, A Avg. Rollne		
	or seat recession, and Avg. Railing		

Instructor Bills

7.5 × 7.8.

ENGINE INSPECTION SUMMARY

Vehicle I.D.: A18731

Engine Type: Dodge, 225 CID

Miles: 45,091

Oil Type: MORCO Rerefined

Oil Drain Interval: 8,000 mi.

Sludge Deposit* Varnish Deposits* Rocker Arm Covers 9.7 Piston Skirts 7.4 Intake Manifold Rocker Arm Covers 8.7 NA Oil Pan Valve Lifters 9.0 9.7 9.5 Valve Deck Area 10.0 Cylinder Wall (BRT) Push Rod Chamber Oil Pan 7.5 NA Timing Gear Cover 9.8 8.4 AVG. SLUDGE AVG. VARNISH

Additional Ratings*

Stuck Valve Lifters	0	Piston Varnish, Max.	9.0
Stuck Compression Rings	0	Piston Varnish, Min.	5.8
Stuck Oil Rings	0	Intake Valve Deposits, Max. Intake Valve Deposits, Min.	
		Intake Valve Deposits, Avg.	

Clogging

Push Rods, No. NA (solid design)
Oil Ring, % 0
Oil Screen, % 0

Observations, Comments

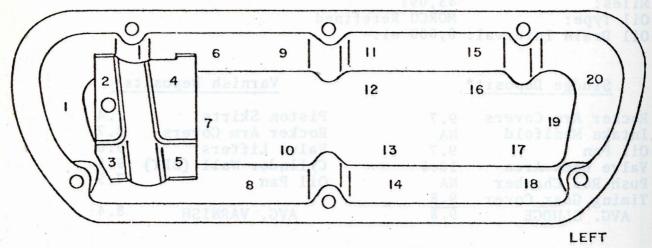
Very light to medium scuffing on left side all pistons V. Very slight corrosion on one compression ring

Date: 5-78

Rater: E.R. Lyons

* 10=Clean NA = Not Applicable

Rating Work Sheet No. I
SLUDGE RATING OF ROCKER ARM COVER



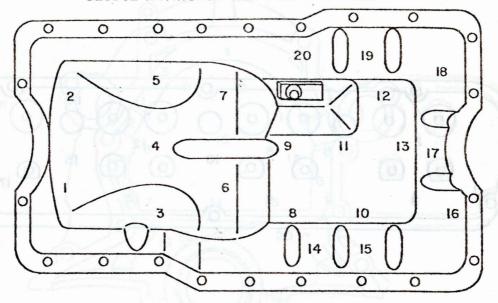
Note: Sites on Vertical Surfaces at Mid-Point

DEPTH	6					Xs/		dzi	im	SI	TE	ota	249			0				Tel	TOTAL	%	VOLUM
SCALE	t	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	SCOVERED	FACTOR
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1/2A		х								х			x						х		4	20	.10
3/4A																				*	E CE IN THE BOARD		
Α	x		х		-												920.00				2 9	10	.10
AB											O- Ara									Λ Λ	12		
В						-4							,		20-				The Park	7.2.7		Ring	THO
ВС											1					14					The second second	Server	ino
С													-		SCHOOL S	March Co.							
D		-											Party S. W.	APCHIO	10 SEP C								
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																0.44	ın	TO	CAL	N-/APTE	20	100	.28

Sludge Merit Rating ---

Inspec	tor ERL	
Date —	5-78	

Rating Work Sheet No. 3
SLUDGE RATING OF OIL PAN



DEPTH										SI	TE										TOTAL	%	VOLU
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN																					14 10		
1/4A	x	х	х	х	х	х	х	х	х	х	x	х	х	x	х	Х	х	х	Х	х	20	100	. 25.
1/2A			14																				
3/4A			X	×.																1			
Α																H							
AB						1 8	1																
В					٠																		
ВС																							
С				-																			
D	:											H											
Ε														-	7						-		
F																-							
G									+														100
н											,					H							
1															7						1-11		
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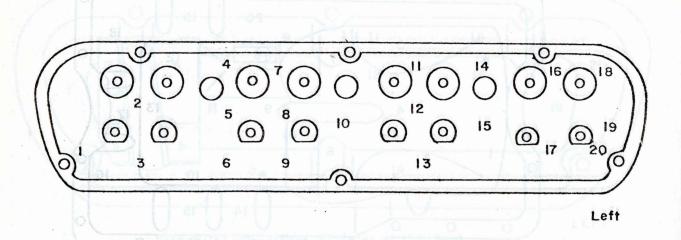
Inspector ERL

Date 5-78

Sludge Merit Rating $\frac{9.7}{}$

Rating Work Sheet No. 4

SLUDGE RATING OF VALVE DECK



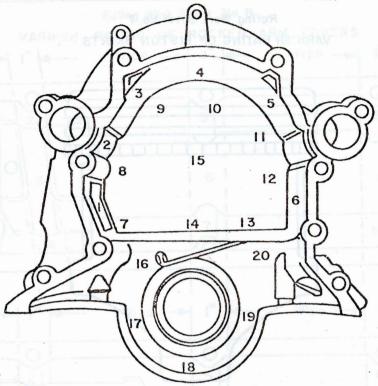
DEPTH							IT IT			S	ITE				THE STATE OF THE S		10				TOTAL	%	VOLUN
SCALE	-	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	CHECKS	COVERED	FACTO
CLEAN	X	X	х	х	x	х	х	x	х	х	x	х	X	х	х	x	x	x	x	х	TO STORE		
1/4A																				177 E	721 3		
1/2A												779 950 1			ETC-P	enty i u				er English		e la relación de la composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della composition della compositio	
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ERL Inspector-

5-78 Date -

Sludge Merit Rating 10.0

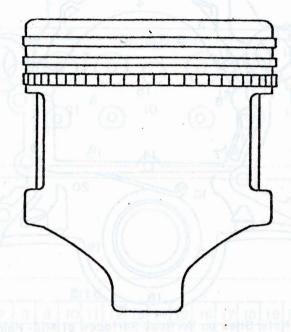
Rating Work Sheet No.6
SLUDGE RATING OF TIMING GEAR COVER



Note: Sites on Vertical Surfaces at Mid-Point

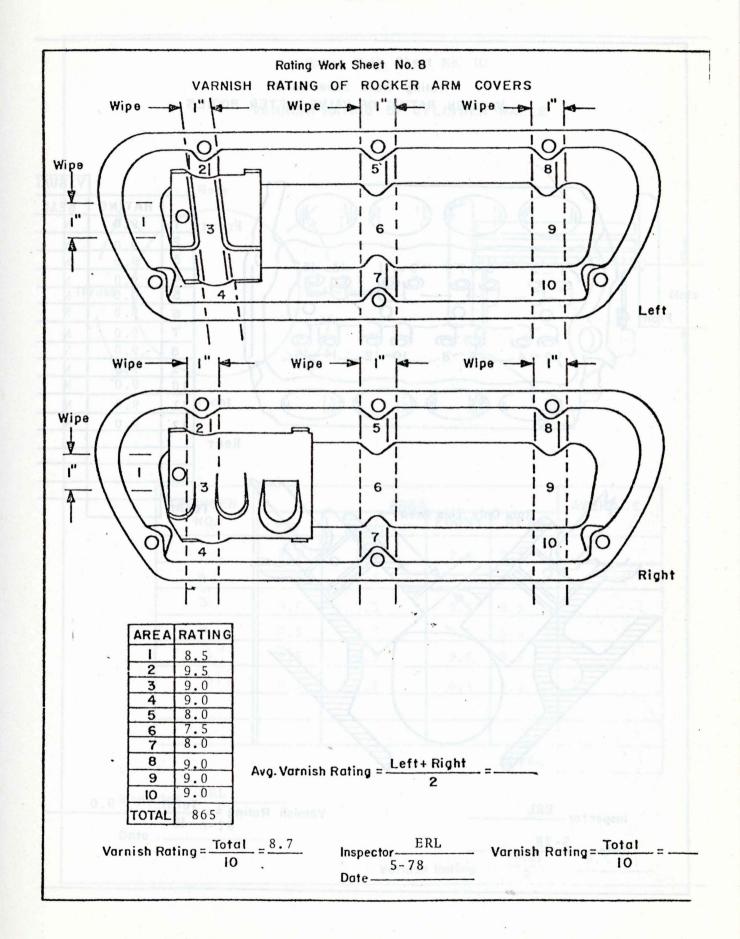
DEPTH	n	яÌ	. VIC	10						SI	TE								HO:	F 219	TOTAL	%	VOLUM
SCALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	CHECKS	COVERED	FACTOR
CLEAN	X	x	х	х	x	х	52		V	7)	1				0.	х	х	х	х	х	11	lufe fi	, v . []
1/4A	ige op tile				À		-			GAGINES CAGINES			+										WIT.
1/2A		4	10.3	olf.			x	x	х	х	x	х	x	х	X						9	45	.22
3/4A		1	MIT	ok	3						8.	8			8.		T		100			J-11eba	31
A		r		- M							n	·			i i	2.			P			Serio e sa	- 1
AB			8	TE 7	175	751											+						
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E					43								-				4						-
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	spe		r_E		. ,		11			= 0	hill	AS	152	REF	G	RAN	1D	TOT	TAL			19	. 8

Rating Work Sheet No. 7 VARNISH RATING OF PISTON SKIRTS

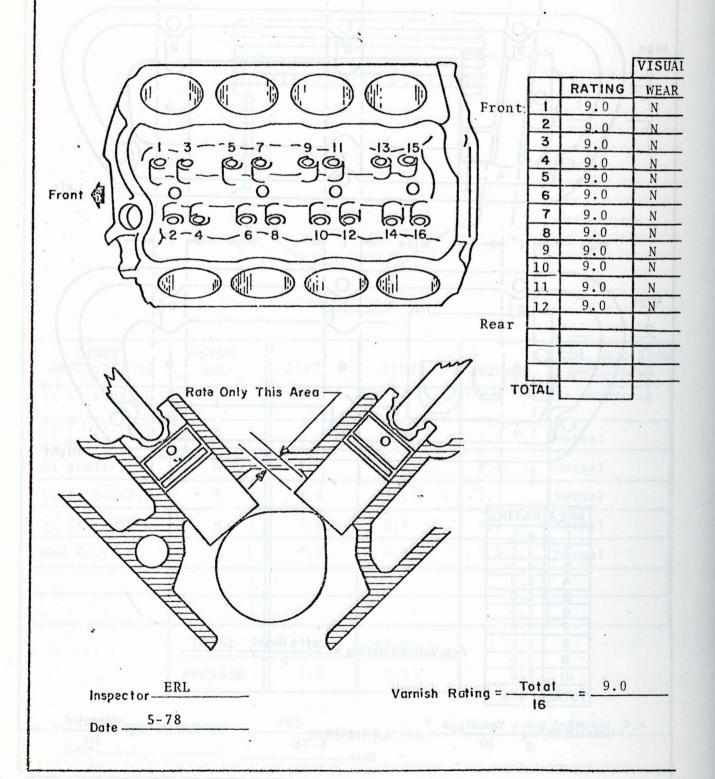


OTHER OBSERVATIONS	PISTON NO.	LEFT	RIGHT	AVERAGE	CON. ROD BRGS
v. 1t scuff-L		9.0	7.4	8.2	Lt scratches
#2CR < 1% corr Lt scuff-L	2	8.0	7.4	7.7	Normal
Lt scuff-L	3	7.8	5.8	6.8	Normal
V. lt scuff-L	4	7.4	7.0 >	7.2	Normal
V. 1t scuff-L	5	7.8	6.5	7.2	Normal ·
Med Scuff-L	6	7.5	6.5	7.0	Normal
	TOTAL	47.5	40.6		
	AVERAGE	7.9	6.8		

Inspector		VARNISH RATING = AvgThrust	+ Avg	Antithrust	7.4
Date	gor	GNASTO VARIOUS RATING -	2	RY-2	

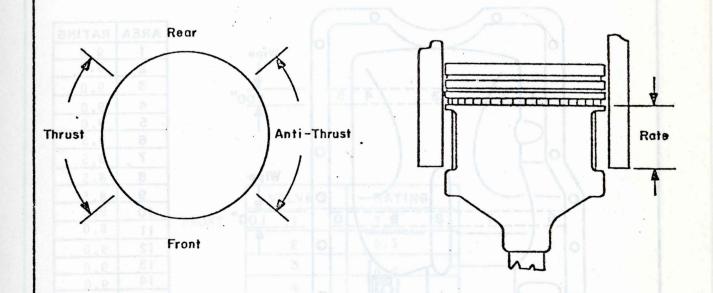


Rating Work Sheet No. 9 VARNISH RATING OF VALVE LIFTER BODIES



Rating Work Sheet No. 10

VARNISH RATING OF CYLINDER WALLS



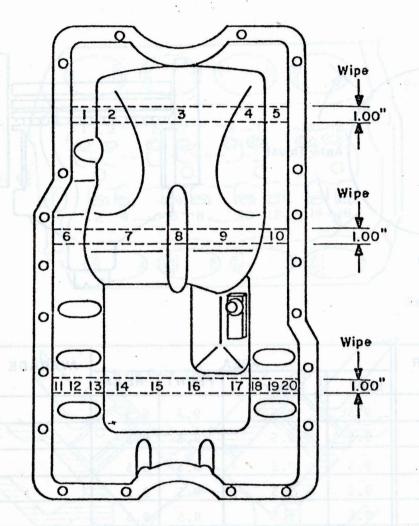
CYLINDER	1-1	AVERAGE				
NO.	LEFT	RIGHT		FRONT	REAR	STH
os,	9.5	9.5		9.5	9.5	
2	9.5	9.5		9.5	9.5	O
3	9.5	9.5	,	9.5	9.5	te fall
ml 4	9.5	9.5	70	9.5	9.5	6/8
5	9.5	9.5		9.5	9.5	
6]]	9.5	9.5		9.5	9.5	
tospect bl	BRL					

Inspector_	ERL
mopodioi _	

5-78

Varnish Rating =
$$\frac{\text{Total}}{8} = \frac{9.5}{}$$

Rating Work Sheet No. 11 VARNISH RATING OF OIL PAN



AREA	RATING
1	9.0
2	9.0
3	9.0
4	9.0
5	9.0
6	8.5
7	8,5.
8	8.5
9	8.5
10	9.0
11	8.0
12	9.0
13	9.0
14	9.0
15	9.0
16	9.0
17	9.0
18	9.0 9.0
19	9.0
20	7.0
TOTAL	1750

Inspector___ERL

Varnish Rating = Total = 7.5

Rating Work Sheet No.12 INTAKE VALVE DEPOSITS

	VALVE	RATING
FRONT	1	7.0
	2	6.5
	3	6.0
	4	6.0
	5	5.0
	6	6.5
REAR	1	
	TOTAL	370

Visual Observation of Seat, recession, or burning: All ok

Avg. Rating= $\frac{\text{total}}{8} = \frac{6.2}{}$

Inspector ERL

Date 5-78

AND SIG TO SMITTAR SHOWN DEPOSITS INTAKE VALVE DEPOSITS

	ation of Seat Tecession	

APPENDIX C

PICTORIAL DOCUMENTATION OF DEPOSIT RATINGS

APPENDIX C

PICTORIAL DOCUMENTATION OF DEPOSIT KATINGS

Table 1. Piston skirt picture documentation.

Vehicle Number	Engine * Location	Test Oil	Final Mileage	Varnish Rating	Engine Rating
17680	Rt #2 - Outside	BERC	45667	5.4	5.8
17687	Lt #3 - Outside	MORCO	48285	9.8	9.8
17683	Rt #3 - Cam Side	VIRGIN	49503	7.8	7.9
18731	#4 - Outside	MORCO	48091	7.4	7.4
18716	#4 - Cam Side	VIRGIN	63910	5.6	5.7
18729	#5 - Cam Side	VIRGIN	31940	6.3	6.1
18710	#1 - Cam Side	MORCO	25617	7.8	9.8
20369	Lt #3 - Outside	MORCO	3 1576	9.0	9.0
20371	Lt #2 - Outside	VIRGIN	27207	6.0	6.4

^{*}Cylinders are numbered from front to back (1,2,3,4). Left (Lt) and Right (Rt) sides of the engine are located while viewing from back to front.

lars are numbered from front to back (1,2,3,4). Left (

gne (se) stues or the engine are located w

Table 2. Intake valve picture documentation.

Rating	goldsk s	Mileag) 10	138002	1900
Vehicle Number	Engine Location*	Test Oil	Final Mileage	Varnish Rating	Engine Rating
. 9.6	1 2	0800 48285	obtat	7 5 7 0	169
17680	Lt # $\frac{1, 2}{4, 3}$	BERC	45667	$\frac{7.5, 7.0}{6.0, 5.5}$	7.0
17687	Lt # $\frac{1, 3}{2, 4}$	MORCO	48285	$\frac{8.0, 5.5}{8.5, 9.0}$	7.4
17683	Lt # $\frac{1, 3}{2, 4}$	VIRGIN	49503	$\frac{1.5, 4.5}{7.5, 8.0}$	4.9
17685	Lt # $\frac{1, 4}{2, 3}$	MORCO	60174	3.0, 8.5 4.0, 1.5	4.1
18731	#3	MORCO	45091	6.0	6.2
18716	#4	VIRGIN	63910	6.0	6.5
18729	#2	VIRGIN	31940	7.5	7.4
20369	Lt #2, 3	MORCO	31576	6.0, 8.0	6.9
20371	Lt #3, 2	VIRGIN	27207	8.0, 6.0	7.1

^{*}Cylinders are numbered from front to back (1,2,3,4). Left (Lt) and Right (Rt) sides of the engine are located while viewing from back to front.

Table 3. Intake valve lifter picture documentation.

Vehicle Number	Engine Location*	Test Oil	Final Mileage	Varnish Rating	Engine Rating
17680	Rt #1	BERC	45667	7.3	7.2
17687	Rt #1	MORCO	48285	7.8	7.9
17683	Lt #4	VIRGIN	49503	7.5	7.3
18731	#3	MORCO	45091	9.0	9.0
18716	#3	VIRGIN	63910	7.5	7.6
20369	Rt #1	MORCO	31576	8.0 (Dished)	8.1
20371	Rt #4	VIRGIN	27207	7.5 (Dished)	7.3

^{*}Cylinders are numbered from front to back (1,2,3,4). Left (Lt) and Right (Rt) sides of the engine are located while viewing from back to front.



VEH. 17680, BERC MILEAGE = 45,667VARNISH RATING = 5.4



VEH. 17687, MORCO MILEAGE = 48,285VARNISH RATING = 9.8



VEH. 17683, VIRGIN MILEAGE = 49,503VARNISH RATING = 7.8



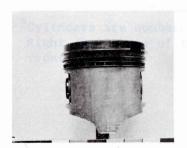
VEH. 18731, MORCO



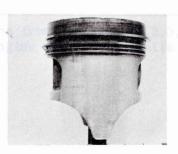
VEH. 18716, VIRGIN MILEAGE = 45,091 MILEAGE = 63,910 MILEAGE = 31,940 VARNISH RATING = 7.4 VARNISH RATING = 5.6 VARNISH RATING = 6.3



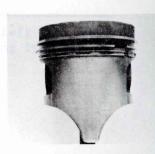
VEH. 18729, VIRGIN



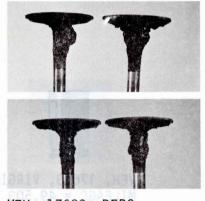
VEH. 18710, MORCO MILEAGE = 25,617VARNISH RATING = 9.8



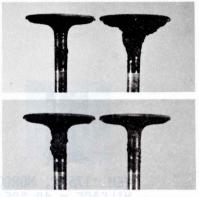
VEH. 20369, MORCO MILEAGE = 31,576 VARNISH RATING = 9.0



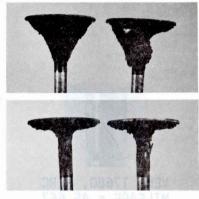
VEH. 20371, VIRGIN MILEAGE = 27,207VARNISH RATING = 6.0



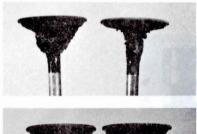
VEH. 17680, BERC MILEAGE = 45,667 DEPOSIT RATING = 7.5, 7.0 6.0, 5.5



VEH. 17687, MORCO MILEAGE = 48,285 DEPOSIT RATING = 8.0, 5.5 8.5, 9.0



VEH. 17683, VIRGIN MILEAGE = 49,503 DEPOSIT RATING = 1.5, 4.5 7.5, 8.0





VEH. 20369, MORCO MILEAGE = 31,576



VEH. 20371, VIRGIN MILEAGE = 27,207DEPOSIT RATING = 6.0, 8.0 DEPOSIT RATING = 8.0, 6.0

VEH. 17685, MORCO MILEAGE = 60,174DEPOSIT RATING = $\frac{3,0, 8.5}{4.0, 1.5}$



VEH. 18781, MORCO MILEAGE = 45,091 DEPOSIT RATING = 6.0



VEH. 18716, VIRGIN MILEAGE = 63,910 DEPOSIT RATING = 6.0



VEH. 18729, VIRGIN MILEAGE = 31,940 DEPOSIT RATING = 7.5



VEH. 17680, BERC MILEAGE = 45,667 VARNISH RATINGS = 7.2



VEH. 17687, MORCO MILEAGE = 48,285 VARNISH RATING = 7.9



VEH. 17683, VIRGIN MILEAGE = 49,503 VARNISH RATING = 7.3



VEH. 18731, MORCO MILEAGE = 45,049 VARNISH RATING = 9.0



VEH. 18716, VIRGIN MILEAGE = 63,910 VARNISH RATING = 7.5



VEH. 20364, MORCO MILEAGE = 31,576 VARNISH RATING = 8.0 (DISHED)



VEH. 20371, VIRGIN MILEAGE = 27,207 VARNISH RATING = 7.5 (DISHED)

the Toes paparament of Transportation. Fire gap measurements were

position (not the cop of the cylinder). In this way ring wear and

The sylinders are numbered from front to back and the left and

right sides of the orgins bee located while straing from back to irent.

APPENDIX D

ENGINE WEAR MEASUREMENTS



VEN. 17680, BERC **
MILEAGE = 45,657
VAPKISH RATINGS = 7.2



VEH. 17687, MORCO MILEAGE = 48,285 VARNISH RATING = 7.9



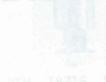
WEH. 17683, VIRGIN MILEAGE = 49,503 VARNISH RATING = 7

APPENDIX D

MGINE WEAR MEASUREMENTS



VEH. 18731, MORCO MILEAGE = 45,049



VEH. 18716, VIRGIN MILEAGE = 63,910 VARNISH RATING = 7.5



VEH. 20364, MORCO MILEAGE = 31.576 VARNISH RATING = 8.0 (DISHEO)



VEH. 20371, VIRGIN MILEAGE = 27,207 VARNISH RATING = 7.5 (DISHED) The engine measurements presented in this appendix were performed by the Iowa Department of Transportation. Ring gap measurements were made while the original compression ring was placed into its operating position (near the top of the cylinder). In this way ring wear and cylinder wear were measured. All data are reported in inches.

The cylinders are numbered from front to back and the left and right sides of the engine are located while viewing from back to front.

VEHICLE NUMBER A17680/BERC OIL

		Righ	t Side		Left Side					
	1	2	3	4	1 5	2	3	4		
Cylinder Diameters:					D&C.	9 2	Si di	11 6 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
Top (Approx. 1/2 in. down)	4.0835	4.0835	4.0835	4.0825	4.084	4.083	4.083	4.0825		
Bottom	4.0800	4.0800	4.0800	4.0800	4.0800	4.0800	4.0800	4.0800		
Wear (Difference)	0.0035	0.0035	0.0035	0.0025	0.004	0.003	0.003	0.0025		
Avg. = 0	.00281									
Piston Diameter: a	1									
Bottom of Skirt	4.079	4.078	4.080	4.079	4.079	4.0815	4.079	4.080		
Just Below Rings	4.078	4.0775	4.0775	4.0775	4.0775	4.078	4.075	4.078		
Wear (Difference)	0.001	0.0005	0.0025	0.0015	0.0015	0.0035	0.004	0.002		
Avg. = 0	.00206									
Ring Gap:	0.025	0.025	0.025	0.025	0.025	0.025	0.028	0.025		
Avg. = 0	.025									
Valve Guide: a			raing a kip							
Intake Standard										
Exhaust Standard										
Main Bearings: Standard										
Rod Bearings: Standard										

^a All dimensions are given in inches.

VEHICLE NUMBER A17683/VIRGIN OIL

	er = 010073	Rigl	nt Side	Left Side					
	1 05,000	2	3	4	1	2	3	4	
Cylinder Diameter: a			•						
Top (Approx. 1/2" down	4.0833	4.083	4.0833	4.083	4.083	4.083	4.083	4.083	
Bottom	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	
Wear (Difference)	0.0013	0.001	0.0013	0.001	0.001	0.001	0.001	0.001	
Avg. Piston Diameter:	= 0.00108								
Bottom of Skirt	4.080	4.080	4.080	4.080	4.080	4.080	4.080	4.080	
Just Below Rings	4.078	4.078	4.0785	4.078	4.0785	4.079	4.079	4.078	
Wear (Difference)	0.0015	0.002	0.0015	0.002	0.0015	0.001	0.001	0.002	
Avg.	= 0.00119								
Ring Gap:	0.026	0.028	0.028	0.023	0.022	0.030	0.026	0.025	
Avg.	= 0.026	0,0015							
Valve Guide: a									
Intake Avg.	wear = 0.0005								
Exhaust Avg.	wear = 0.002								
Main Bearings: Avg.	wear = 0.001								
Rod Bearings: Avg.	wear = 0.001								

a All dimensions are given in inches.

VEHICLE NUMBER A17685/MORCO OIL

Rod Bearings:		. Wear a Dibor	Right		Left Side					
		11	2	3	4	1 1	2	3	4	
Cylinder Diameter:	EAS.	. Wear = 0,002			_	.,	*			
Top (Approx. 1/2"			4.0835	4.0835	4.0835	4.0835	4.083	4.083	4.082	
Bottom		4.082	4.082	4.083	4.082	4.082	4.083	4.082	4.082	
Wear (Difference)		0.0015	0.0015	0.0015	0.0015	0.0015	0.00	0.001	0.00	
Piston Diameter:	Avg.	= 0.00125								
Bottom of Skirt		4.080	4.084	4.080	4.080	4.080	4.0795	4.0805	4.080	
Just Below Rings		4.078	4.078	4.079	4.078	4.078	4.0795	4.0795	4.078	
Wear (Difference)		0.002	0.006	0.001	0.002	0.002	0.00	0.001	0.002	
	Avg.	= 0.002								
Ring Gap:		0.024	0.023	0.035	0.023	0.026	0.032	0.032	0.024	
	Avg.	= 0.0274			0.001					
Valve Guide: a										
Intake	Avg.	wear = 0.001								
Exhaust	Avg.	wear = 0.001								
Main Bearings:	Avg.	wear = 0.0005		3						
Rod Bearings:	Avg.	wear = 0.0013								

a All dimensions are given in inches.

VEHICLE NUMBER A17686/BERC OIL

Bearings: . Avg.	WELL = 0,0003	Rig	ght Side		1	Left Side					
in Bearings: Avg.	wear = 0.001	2	3	4	1	2	3	4			
Cylinder Diameter: a	Wear = 0.0025.										
Top (Approx. 1/2"	lown) 4.082	4.084	4.083	4.083	4.083	4.083	4.083	4.0835			
Bottom	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082			
Wear (Difference)	0.00	0.002	0.001	0.001	0.001	0.001	0.001	0.0015			
As cable	rg. = 0.00106										
Piston Diameter:											
Bottom of Skirt	4.079	4.080	4.079	4.082	4.080	4.080	4.081	4.080			
Just Below Rings	4.078	4.078	4.078	4.079	4.078	4.0785	4.0785	4.078			
Wear (Difference)	0.001	0.002	0.001	0.003	0.002	0.0015	0.0025	0.002			
ton Diameter: A	rg. = 0.00188										
Ring Gap: a	0.022	0.025	0.025	0.025	0.025	0.025	0.025	0.028			
West (Difference) V	rg. = 0.025					0.002					
Valve Guide: a					71087						
	ng. wear = 0.001				4.083						
	vg. wear = 0.001										
	g. wear = 0.001										
Erick Branch and a											
Rod Bearings Av	7g. wear = 0.001	Le									

a All dimensions are given in inches.

VEHICLE NUMBER A17687/MORCO OIL

			ax = .0.00	Left Side						
			601 -10'00	2	3	4	1	2	3	4
Cylinder Diameter:	Avi	7 - 4	edr = 0.00	5					2	
Top (Approx. 1/2"	down	1)	4.083	4.0825	4.083	4.083	4.083	4.083	4.084	4.083
Bottom			4.0825	4.082	4.082	4.082	4.081	4.081	4.0825	4.082
Wear (Difference)			0.0005	0.0005	0.001	0.001	0.002	0.002	0.0015	0.001
	Avg.	= 0	.00119							
Piston Diameter: a			0,00188						s and	
Bottom of Skirt			4.082	4.080	4.084	4.081	4.079	4.081	4.081	4.081
Just Below Rings			4.078	4.078	4.078	4.078	4.0775	4.078	4.099	4.079
Wear (Difference)			0.004	0.002	0.006	0.003	0.0015	0.003	0.002	0.002
	Avg.	- 0	.00294							
Ring Gap: a			0.028	0.025	0.025	0.028	0.027	0.025	0.038	0.025
	Avg.	= 0	.0276							
Valve Guide: a										
	Avg.	wear	: = None						¥108	
Exhaust	Avg.	wear	c = 0.0025							
Main Bearings:	Avg.	wear	c = 0.001							
Rod Bearings:	Avg.	wear	c = 0.0008							

^a All dimensions are given in inches.

		Left Side						
The second secon	1	2	3	4	1	2	3	4
Cylinder Diameter: a								
Top (Appox. 1/2" down	a) 4.0835	4.084	4.0835	4.082	4.084	4.084	4.0825	4.082
Bottom	4.082	4.082	4.082	4.081	4.082	4.082	4.082	4.081
Wear (Difference)	0.001	0.002	0.0013	0.001	0.002	0.002	0.0005	0.00
TE GAP	. = 0.00135							
Piston Diameter:								
Bottom of Skirt	4.080	4.082	4.080	4.083	4.082	4.081	4.080	4.078
Just Below Rings	4.078	4.0985	4.078	4.078	4.078	4.079	4.078	4.078
Wear (Difference)	0.002	0.0035	0.002	0.005	0.004	0.002	0.002	0.00
Avg	. = 0.00206							
Ring Gap: a	0.027	0.027	0.022	0.020	0.024	0.028	0.020	0.020
Avg	. = 0.0235							
Valve Guide: a								
	. wear = 0.0005							
Exhaust Avg	. wear = 0.002							
Main Bearings: Avg.	wear = 0.001							
Rod Bearings: Avg	. wear = 0.0013							

a All dimensions are given in inches.

VEHICLE NUMBER A18710/MORCO OIL

Hod Bearings: Av	E west = 0.001	2	3	4	5	6		
Cylinder Diameter: a	B. Wear = 0.002							
Top (Approx. 1/2" dow	m) 3.402	3.402	3.402	3.402	3.402	3.402		
Bottom	3.401	3.401	3.401	3.401	3.401	3.401		
Wear (Difference)	0.001	0.001	0.001	0.001	0.001	0.001		
Avg. Piston Diameter:	= 0.001						0.020	
Bottom of Skirt	3.400	3.401	3.394	3.401	3.400	3.401		
Just Below Rings	3.399	3.399	3.399	3.400	3.399	3.399		
Wear (Difference)	0.001	0.001	0.001	0.001	0.001	0.001		
Avg.	= 0.001							
Ring Gap:	0.025	0.025	0.025	0.025	0.025	0.025		
	= 0.025							
Valve Guide: a								
Intake Avg.	wear = 0.001							
Exhaust Avg.	wear = 0.0035							
Main Bearings: No w	ear.							
Rod Bearings: No w	ear.							

 $^{^{\}mathrm{a}}$ All dimensions are given in inches.

VEHICLE NUMBER A18716/VIRGIN OIL

	1	2	3	4	5	6
Cylinder Diameter: a	eat.					
Top (Approx. 1/2" d	own) 3.402	3.403	3.403	3.4025	3.4025	3.4025
Bottom	3.400	3.400	3.400	3.401	3.400	3.400
Wear (Difference)	0.0025	0.003	0.003	0.0015	0.0025	0.0025
Av	g. = 0.0025					
Piston Diameter: a						
Bottom of Skirt	3.400	3.400	3.400	3.400	3.399	3.399
Just Below Rings	3.399	3.3985	3.3985	3.398	3.398	3.399
Wear (Difference)	0.001	0.0015	0.0005	0.001	0.001	0.001
sorrow of akers Av	g. = 0.0011			37401		
Ring Gap:	0.023	0.023	0.023	0.023	0.023	0.023
Av	g. = 0.023					
Valve Guide:		0.002				
	g. wear = 0.001		3.401			
	g. wear = 0.005					
	wear.					
Rod Bearings: No	wear.					

^a All dimensions are given in inches.

VEHICLE NUMBER A18729/VIRGIN OIL

Rod Bearings:	No pear - 1	2	3 - 3-	4	5	6
Cylinder Diameter: a			100 - 100 -	1		
Top (Approx. 1/2" d	own) 3.403	3.403	3.403	3.402	3.4025	3.402
Bottom	3.401	3.401	3.401	3.401	3.401	3.401
Wear (Difference)	0.002	0.002	0.002	0.001	0.0015	0.001
Av	g. = 0.00158					
Piston Diameter:	0.023					0,023
	3.400	3.3995	3.4005	3.401	3.401	3.401
Just Below Rings	3.399	3.3995	3.4005	3.4005	3.400	3.4005
Wear (Difference)	0.001	0.00	0.00	0.0005	0.001	0.0005
Boccoa of Skill An	g. = 0.0005					
Ring Gap:	0.025	0.025	0.025	0.025	0.025	0.025
they carr	g. = 0.025					
Valve Guide:						
	g. wear = 0.001					
	g. wear = 0.001	Avg. wear	#3 = 0.006			
Main Bearings: No	wear.					
Rod Bearings: No	wear.					

^a All dimensions are given in inches.

VEHICLE NUMBER A18731/MORCO OIL

Bearings:		= 0.090 p	2	3	4	5	6	
Cylinder Diameter	a Meak	- 0,0005						
Top (Approx. 1		3.402	3.402	3.402	3.403	3.402	3.403	
Bottom		3.401	3.401	3.401	3.4025	3.401	3.401	
Wear (Differen	nce)	0.001	0.001	0.001	0.0015	0.001	0.001	
	Avg. =	0.00108						
Piston Diameter:	i							
Bottom of Skir	tras a on	3.400	3.401	3.3995	3.400	3.4005	3.400	
Just Below Rir	ngs	3.3995	3.400	3.3995	3.400	3.4005	3.400	
Wear (Differen	nce)	0.0005	0.001	0.00	0.00	0.00	0.00	
Bocton of Skirt est (Ditlatouter)	Avg. =	0.00025			4 0 6 6			
Ring Gap:		0.025	0.025	0.025	0.025	0.025	0.025	
	Avg. =	0.025						
Valve Guide;								
Intake	Avg. we	ear = 0.001						
Exhaust		0.005	0.001	0.001	0.001	0.005	0.001	
Main Bearings:	No wear	× 0.003						
Rod Bearings:	No wear	e 0.70/05 3						

^a All dimensions are given in inches.

VEHICLE NUMBER A20369/MORCO OIL

		Righ	nt Side			Left	Side	
Red Bearings; No wer	1	2	3	4	1	2	3	4
Cylinder Diameter: a	u. ·				-			
Top (Approx. 1/2" down)	4.059	4.056	4.056	4.058	4.0615	4.054	4.055	4.057
Bottom	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052
Wear (Difference)	0.005	0.004	0.004	0.006	0.0085	0.002	0.003	0.005
Avg. = 0	0.00469							
Piston Diameter:	fore							
Bottom of Skirt	4.050	4.0485	4.048	4.048	4.0485	4.051	4.049	4.049
Just Below Rings	4.0475	4.048	4.048	4.047	4.0475	4.048	4.047	4.0475
Wear (Difference)	0.0025	0.0005	0.00	0.001	0.001	0.003	0.002	0.0025
porcess of ext Avg. = (0.00175							
Ring Gap:	0.077	0.122	0.103	0.075	0.125	0.043	0.052	0.042
Avg. = 0	0.0799							
Valve Guide:								
	ar = 0.002					3'401		
"Disclarate Kartificación i vi Astronomen	ar = 0.003							
Main Bearings: Avg. wea	ar = 0.000	5						
Rod Bearings: Avg. wea	ar = 0.0005	5						

^a All dimensions are given in inches.

			Righ	t Side			Left	Side	
		1	2	3	4	1	2	3	4
Cylinder Diameter:									_ = -
Top (Approx. 1/2		4.062	4.061	4.060	4.0595	4.061	4.061	4.057	4.061
Bottom		4.052	4.052	4.051	4.051	4.051	4.052	4.051	4.052
Wear (Difference	:)	0.010	0.009	0.009	0.0085	0.010	0.009	0.006	0.009
	Avg. = 0	0.0088							
Piston Diameter:									
Bottom of Skirt		4.047	4.0475	4.047	4.047	4.047	4.048	4.049	4.048
Just Below Rings		4.047	4.0475	4.047	4.047	4.047	4.048	4.0475	4.048
Wear (Difference)	0.00	0.00	0.00	0.00	0.00	0.00	0.0015	0.00
	Avg. = 0	0.00							
Ring Gap: ^a		0.078	0.078	0.078	0.078	0.075	0.075	0.075	0.078
	Avg. = (0.758							
Valve Guide:									
Intake	Avg. wea	ar = 0.0015	5						
Exhaust	Avg. wea	ar = 0.003							
Main Bearings:	Avg. wea	ar = 0.0005	5						
Rod Bearings:	Δυσ ωε	ar = 0.0005	5						

^a All dimensions are given in inches.

a Williamstana file State in locker.

Marc Bearings:					
				270.0	
				0,052	
			0.010		
Rod Bearings:	Avg. vest = 0,0003				

HIGH SINGSTONS STR FLYRD IN INCHES

COLLECTION OF WASTE OIL PRON PARTS

There have been several studies containing the actual of used of available from service erations and manufacturing firms and the fewal-tility of collecting and recycling such oil. However, the quartity of available and the difficulty of collecting oil ince fare secondations have moved been assessed. The purpose of this at my was to conclude the accordance and fessibility of collecting oil from terms in Town.

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APPENDIX E

COLLECTION OF WASTE OIL FROM FARMS

generally consume more oil per hour and have hydraudic systems and grave boxes associated with them. Bayond that, little is become smust agriculture: consumption patterns.

clon patrerns and attitudes toward using is-refined oil. This question make and notited to 500 form owner-operature in each of four countries.

(Butler, Cuchrie, Keckuk and Wayne). The mailing lists were developed tendently from country directories [2-3]. Of the 400 questionnaires mailed, ill were returned and 69 (19.4%) were considered valid. The age distribution acres of land farmed and number and type of vehicles correspond to well with other statistical data for them. This suggests

APPENDIX E

COLLECTION OF WASTE OIL FROM FARMS

COLLECTION OF WASTE OIL FROM FARMS

There have been several studies concerning the amount of used oil available from service stations and manufacturing firms and the feasibility of collecting and recycling such oil. However, the quantity of oil available and the difficulty of collecting oil from farm populations have never been assessed. The purpose of this study was to consider the economics and feasibility of collecting oil from farms in Iowa.

Nationwide, the agricultural industry consumes more petroleum than any other single industry [1]. In Iowa, 19.2% of the population lives on farms and operates 32% of the internal combustion engines. Although these engines probably average fewer hours than highway vehicles, they generally consume more oil per hour and have hydraulic systems and gear boxes associated with them. Beyond that, little is known about agricultural consumption patterns.

A questionnaire was developed to survey agricultural oil consumption patterns and attitudes toward using re-refined oil. This questionnaire was mailed to 400 farm owner-operators in each of four counties (Butler, Guthrie, Keokuk and Wayne). The mailing lists were developed randomly from county directories [2-5]. Of the 400 questionnaires mailed, 113 were returned and 69 (19.4%) were considered valid. The age distribution, acres of land farmed and number and type of vehicles corresponded well with other statistical data for Iowa. This suggests a valid sample population.

COLLECTION OF WASTE OIL FROM FARMS

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RESULTS

The age and farm size distribution of the respondents are shown in Tables 1 and 2.

Question 3 asked farmers to provide information about oil use in all engines of various pieces of equipment. The detailed breakdowns obtained are presented in Table 3. The average farmer operates approximately three tractors, one car and either a pickup or a truck. With the exception of the cars, the majority change their own oil. The type of oil used, change frequency and other factors are about as expected.

About 45% of the farmers purchase their oil in drums or 5-gallon cans, and 23% purchase oil exclusively in cases of quart cans. The average quantity of oil purchased is 50.9 gallons per year, with the distribution shown in Fig. 1.

Farmers dispose of used oil in a variety of ways, as shown in Table 4. The most common use is for rust prevention (oil plowshares, etc.), with dust control second. A rather large fraction (11%) simply dump their oil on the ground. Only two respondents indicate that they return at least a portion of the waste oil to a service station or landfill. About 7% use the oil as an aid in burning brush, lumber or weeds.

Only two of the respondents felt their method of disposal might be harmful to the environment. The majority apparently felt they made good use of the waste oil and that the quantity dumped was insignificant.

The factors which influence a farmer in purchasing oil are listed in Table 5. Farmers have a large investment in equipment which they

Table 1. Iowa farm size distribution.

Acres	Percent
0-160	25.0
160-320 and algorithm	41.17
320-640	
Other to quadric santis has	and the course 7.36 mis gladest

Table 2. Age profile of Iowa farmers.

sively in cases of quart agA. The	Percent
ada dalwas very reg anoling 0.02 at a	oserage of oil purchased
25-29	1.45
30-50	23.19
Over 50	75.36

eturn at least a portion of the waste oil to a service station or land

Ill. About 72 use the oil us an aid to burning brush, lumber or weeds.

Only two of the respondents felt their method of disposel might

od the washe of the washe of and that the quantity dumped was insignifican

The factors which influence a farmer in purchasing oil are listed

o Table 5. Farmers have a large investment in equipment which they

Table 3. Oil used on Iowa farms in Butler, Guthrie, Keokuk and Wayne Counties.

Vehic			Type Oil	Used		Change Frequency	Filter Chang		Quantity Per Change	Oil Added Between Changes		nged By
Туре	No.	10W-30	10w-40	30	Other	Hrs/Miles	Every Time	Alternate	Quarts	Quarts	Self	Statio
Tractors	tide .	\$0	40	60		80 - 11	00 - 5 Js	0 -1	48 B 160	\$ 380;	500	
Butler	46	13	0	28	5	108.8	34	10	7.65	1.28	A11	
Guthrie	37	3	2	27	5	104.7	30	7	8.43	0.95		
Keokuk	65	8 .	9	41	7	125.4	54	10	8.84	2.26		
Wayne	43	6	5	31	1	102.2	33	10	8.49	1.65		
Total	191	30	16	127	18	112.2 a	151	37	8.40 a	1.63ª		
Perc	ent	15.7	8.4	66.5	9.4		80.3	19.7		- 6		
Cars												
Butler	18	13	4	1	0	3111.0	12	6	5.22	1.00	9.0	9.0
Guthrie	12	1	6	1	4	3041.7	12	0	5.08	0.66	4.5	7.5
Keokuk	29	13	5	3	8	3224.1	21	8	5.14	0.75	14.0	15.0
Wayne	16	9	6	0	1	3281.2	14	2	5.13	0.50	7.5	8.5
Total	75	36	21	5	13	3180.0 a	59	16	5.15 a	0.74ª	35.0	40.0
Pero	cent	48	28	6.7	17.3		78.7	21.3			46.0	53.0
Pickups												
Butler	14	8	4	1	1	2500.0	12	2	5.36	0.64	5.0	9.0
Guthrie	12	3	3	2	4	2541.7	11	1	5.33	0.83	6.5	5.5
Keokuk	17	8	2	4	3	3058.8	10	7	5.35	1.76	8.5	8.5
Wayne	13	4	4	3	2	3000.0	12	1	5.23	1.38	8.0	5.0
Total	56	23	13	10	10	2794.6ª	46	11	5.32ª	1.19 ^a	28.0	28.0
Perc	ent	41.1	23.2	17.8	17.8	ander our	80.4	19.6			50.0	50.0
Trucks												
Butler	2	1	0	0	1	1750.0	2	0	5.50	0.50	2.0	0.0
Guthrie	6	0	1	4	1	2666.7	6	0	6.83	1.83	3.0	3.0
Keokuk	6	1	2	2	1	2083.0	3	3	7.00	1.66	6.0	0.0
Wayne	4	3	0	0	1	2500.0	3	1	6.00	2.00	2.5	1.5
Total	18	5	3	6	4	2333.3ª	14	4	6.55ª	1.66ª	13.5	4.5
Perc	ent	27.8	16.7	33.3	22.2		77.8	22.2			75.0	25.0

a Average

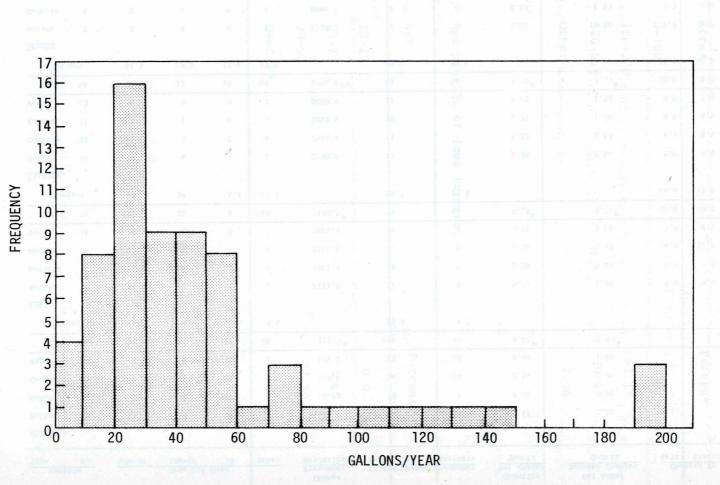


Fig. 1. Distribution of oil consumption on Iowa farms.

Table 4. Used oil disposal techniques.

quality with grice is covidently a law-i	Absolute Frequency	%
Oil cultivator shovels & plowshares	55	27.64
Service station changes oil	anglash 3-32 vd)	16.08
Use for dust control	abresial 28	14.07
Other Other	0013850 25	12.56
Dump on ground	22	11.06
Use for weed control	17	8.54
Burn it	14	7.04
Insect control stagnant pools	4	2.01
Take to dump or landfill	1	0.50
Take to service station	1	0.50
Sell it	propries. The M	0.00
of m Total prime by the respondents is	199	100.00

to 1. It class seems likely that a large fraction of farmers would us

appear to be willing to participate in a recycling progress of

ing. These results suggest that a recovering progress would have by

the bost of a container on each form and the court of restrict form to

a program to untikely to collect more than 50% of the collection and

The equipment of while a surplicity program are and though to distinct

Table 5. Factors in decision to purchase a particular type of oil, based on response from 69 questionnaires.

2.	Yenoney	Absolute Frequency	%
	PP PP PP PP PP PP PP PP PP PP PP PP PP	rrequency	rtavidlus I Ki
Highest quality	(by SAE designation, etc.)	46 66 60	34.07
Dealer (recommen	dation, friendship, reputatio	on) 26	19.26
Manufacturer's r	ecommendation	20	14.82
Brand name	22	19	14.07
Viscosity		15 oriana	b 11.11 980
Other .		6	4.45
Lowest price		og im 3 igeta 1	2.22
Labelling		IIIOmal To	0.00
Total		135	100.00

protect by selecting what they feel is a high quality oil. The first five factors listed might all be interpreted as efforts to obtain high quality oil. Price is obviously a low-level criterion.

Only two of the respondents indicated that re-refined oil was available in their area, while 70% didn't know whether it was or not.

About 27% didn't think it was available and no one had purchased any.

Table 6 indicates the relative willingness to purchase re-refined oil of the same price and quality as virgin oil. The comments associated with the yes' and 'probably would' answers indicate a rather high energy resource conservation awareness. The negative responses (58%) were explained by skepticism about the quality of re-refined oil. Generally, the respondents wanted proof of quality before trying re-refined oil, and they also felt that "used" oil should be cheaper than "new."

Table 7 lists the results of an attempt to assess the willingness of farmers to participate in a recycling program. The interpretation of this question by the respondents is not really clear. Less than 25% appear to be willing to participate in a recycling program even if everything were provided, although the ratio of 'yes' to 'no' answers is 3 to 1. It also seems likely that a large fraction of farmers would continue to use oil on the farm but would contribute the excess to recycling. These results suggest that a recycling program would have to bear the cost of a container on each farm and the cost of removal from the farm in order to achieve significant participation. Even this kind of a program is unlikely to collect more than 50% of the available used oil.

The economics of such a recycling program are not likely to attract a large number of investors. There are a total of 131,000 farms in Iowa.

Table 6. Willingness to purchase re-refined oil.

ance indicated that re-relined off was	Frequency	%
Yes ton to saw it sentent wond indicator st	6	9.38
Probably would		32.81
Probably would not		32.81
y as virgin oil. The comments as a saled of	15	25.00
Total limiter a spenthal arewene bloom	64 bns	100.00

Table 7. Willingness to participate in a recycling program, based on 65 responses to this question.

		Absolute Frequency		7 119ts	
		Ves	No	Yes	No
1.	A drum was provided for you to collect waste oil in and someone emptied it for you.	33		22.00	7.33
2.	You were asked to provide the drum and someone would empty it out regularly for you.	19	14	12.67	9.33
3.	You were asked to provide a drum and asked to haul it to a collection site where it would be dumped for you.	3 8/1 7 3 8 8 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	20	4.67	13.33
4.	You would continue to use the oil on the farm.	35*	11	23.33	7.33
	Total	150		100.00	

^{*}Twelve respondents indicated they would continue to use <u>some</u> oil on the farm but would be willing to participate in a recycling program with the remainder.

With half of the farmers participating and 40% of their purchased oil available for recycling, there would be 1,330,000 gal/yr of oil recycled. This is based on the 50.9 gal/farm/year averaged cited above. A lower bound on the collection cost might be obtained by assuming 20 gallons per collection site to be picked up annually. This would require each of five trucks to make 45 stops per day and collect about 890 gallons. This leaves about 11 minutes per stop and may require 100 miles of traveling. An updated operating cost of \$1.86/mile [6] then gives a transportation cost of \$0.31/gal collected. An additional cost of about \$0.05/gal would be required for purchase of storage facilities. A cost of \$0.36/gal seems prohibitively high at today's oil prices.

A more promising alternative would be to have service station trucks collect the oil on their regular farm stops. A local Iowa collector indicates a cost of \$0.10 to \$0.12 per gallon to collect oil from service stations.

Considering the difficulties that urban areas have experienced in collecting waste oil, it seems clear that a strong public commitment or government support will be required to effectively recycle waste oil from rural areas.

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- or government support will be required to effectively recycle waste
- J. Now were asked to provide a dram and second to hard it to a collect that after where it would be drawn 7 20 4.61 (2.3) for your
- Total 159 100.00

Twaive respondents indicated they would continue to use some oil on the form but would be willing to purticipate in a recycling program with the remainder.

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