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B-1 AIRCRAFT MAIN HYDRAULIC PUMP TESTS WITH MIL-H-87257 HYDRAULIC FLUID

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MATERIALS & MANUFACTURING DIRECTORATE
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WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7734

NOTICE

This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*
In an effort to convert the B-1 aircraft from MIL-H-5606 to the fire resistant MIL-H-87257 hydraulic fluid, the Air Force sponsored a study conducted by Rockwell International from April 1992 through June 1992 under contract F34601-89-C-0401. The results of this study are published in Rockwell Report NA-91-1598, date 17 June 1992. As part of this study, two pump tests were conducted by Vickers using B-1 aircraft hydraulic pumps (Vickers PV3-300-7B) and MIL-H-87257 (ROYCO 777) hydraulic fluid. During the first test, the pump failed prematurely. The second test was stopped before the scheduled test duration because some metal was observed in the filter patch test. Due to lack of funding, no additional pump tests were carried out to check the compatibility of MIL-H-87257 and the B-1 hydraulic pumps. This being the only unresolved issue standing in the way of transitioning the MIL-H-87257 fluid to the B-1 aircraft, the Nonstructural Materials Branch of the Materials and Manufacturing Directorate of Air Force Research Laboratory (AFRL/MLBT) undertook in-house pump tests with B-1 hydraulic pumps to provide the necessary data. A base line test was conducted using MIL-H-5606 and a second test was run under identical conditions using MIL-H-87257. Both pump tests were successful. Based on these tests MIL-H-87257 was deemed suitable for use in B-1 aircraft. The results of the pump tests are the subject of this report.

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1.0 INTRODUCTION

MIL-H-83282 is a synthetic, less flammable hydraulic fluid that replaced the flammable MIL-H-5606 hydraulic fluid in most Air Force aircraft. MIL-H-83282 does not meet the viscosity requirements for -65 °F operation. However, MIL-H-87257, the low temperature version of MIL-H-83282 fluid, does meet these requirements.

In an effort to convert the B-1 aircraft from MIL-H-5606 to MIL-H-87257, the Air Force sponsored a study conducted by Rockwell International from April 1991 through June 1992, under contract F34601-89-C-0401. The results of this study are published in Rockwell Report NA-91-1598, dated 17 June 1992. As part of this study, two pump tests were conducted by Vickers using B-1 aircraft hydraulic pumps (Vickers PV3-300-7B) and MIL-H-87257 (ROYCO 777) hydraulic fluid. During the first test, the pump failed prematurely. The second test was stopped before the scheduled test duration because some metal was observed in the filter patch-test. Due to lack of funding no additional pump tests were carried out to check the compatibility of MIL-H-87257 and B-1 hydraulic pumps. This being the only unresolved issue standing in the way of transitioning this fluid to the B-1 aircraft, the Nonstructural Materials Branch of the Materials Directorate of Wright Laboratory (WL/MLBT) decided to conduct in-house pump tests with MIL-H-87257 and B-1 hydraulic pumps to provide the necessary data. The results of the two pump tests carried out at WL/MLBT are the subject of this report.

2.0 TEST OBJECTIVE

The objective of this program was to complete the initial studies begun by Rockwell to determine the compatibility of MIL-H-87257 with the B-1 hydraulic pumps.

3.0 PUMP TESTS

The Vickers PV3-300-7B hydraulic pump is a constant pressure, variable displacement pump capable of very high flow rates of up to 64 gpm and requiring high horsepower input. Due to the horsepower limitations of the WL/MLBT hydraulic pump test stand, it was not practical to duplicate either the qualifying tests or the tests conducted at Vickers. After reviewing the test conditions and the pump failure modes generated at Vickers during the hydraulic pump testing of MIL-H-87257 hydraulic fluid, the following plan was agreed upon by all the interested organizations.

3.1 PUMP TEST PLAN

Hydraulic Pump:	Vickers Model PV3-300-7B Pump (new pump for each test).	
Test Fluids:	MIL-H-5606F, Baseline, WL/MLBT Pump Test 33 MIL-H-87257 (ROYCO 777), WL/MLBT Pump Test 34	
Test Duration:	Total 90 hours.	
	STAGE I:	30 hours
	STAGE II:	30 hours
	STAGE III:	30 hours
Pump Inlet Pressure:	95-100 psig.	
Pump Outlet Pressure:	4150 psig.	
Pump Outlet Flow:	50 gpm.	
Pump Shaft Speed:	5250 rpm.	

Pump Inlet Temperature:	STAGE I:	180 °F
	STAGE II:	210 °F
	STAGE III:	250 °F

Filter Elements:

Main Filter - Pall Corporation, P/N AC-9516F-1, 3 micron, replaced after each test

Heat Exchanger Bypass Filter - Pall Corporation P/N AC-7031F-1297Y6, 5 micron, replaced after each test

Case Drain Filter - Pall Corporation P/N AC-7031F-1297, 5 micron, replaced after each test

Patch Filter - Millipore (housing P/N XX047-00, element P/N LSWP-047-00), 5 micron, inspected and replaced after each stage

Fluid Samples: Taken at approximately 0, 6, 15, and 30 hours of each stage

Pump Disassembly and Inspection: Pretest and after each stage

3.2 HYDRAULIC PUMP TEST STAND MODIFICATIONS

The existing pump test stand at WL/MLBT was designed primarily for testing new and experimental hydraulic fluids using small to medium displacement aircraft hydraulic pumps operating at low flow rates. The PV3-300-7B is a large displacement pump, which would be operated at high flow rates during these tests. To accommodate these flow rates, an increase in power, tubing size, filter capacity and heat exchanger capacity was necessary. The modified test circuit is shown in figure 1. The variable speed drive motor on the existing test stand would supply the additional power needed as it would produce 150 hp versus the approximate 145 hp the pump required at the test plan flow rate of 50 gpm. In order to satisfy the other requirements, major changes to the pump test stand were necessary. The hydraulic circuits of the existing test stand were altered in the following manner:

a. High pressure flow (pump outlet) - To accommodate the higher pressure and flow rate from the pump this circuit was rebuilt using larger tubing size. The throttling valve was modified using an upgrade kit. A circuit was also added to bypass this valve. The relief valve was upgraded and re-calibrated. The sensors remained unchanged.

b. Case drain flow - What had been the main return hydraulic circuit was modified to serve as the new case drain circuit. The same heat exchanger, filter assembly, flow meter and other sensors were utilized. Several valves and additional sensors were also incorporated into this circuit for temperature-pressure indication and control.

c. Main return flow (pump inlet) - An entirely new circuit was designed and fabricated. Downstream of the throttle valve the new main return flow was split into two similar circuits. The flow through these circuits passed through individual heat exchangers and filters before being rejoined. Also, at this junction the flow from the heat exchanger bypass circuit was added with the combined flow subsequently passing through a new high capacity flow meter. Case drain flow and any needed make-up fluid from the reservoir were then added to the return flow. Further downstream were several sensors and a sampling valve before connection to the pump inlet.

To accomplish these changes and other necessary modifications to the test stand, the following major items were designed, fabricated, purchased or otherwise obtained:

a. A new pump mounting flange and drive spline were designed and fabricated with the help of necessary installation drawings furnished by Vickers Corporation.

b. New hydraulic fittings which mate with the pump inlet-outlet and which also use the same spring energized seals as on the aircraft were designed and fabricated. An adapter was purchased for the Rosan fitting on the pump case drain.

c. New throttle valve parts were purchased to upgrade this valve.

d. Two large (3' long x 8" diameter) heat exchangers were purchased. The large size heat exchangers were needed for the 180 °F inlet temperature requirement for Stage I.

e. Two large capacity filter assemblies including elements were graciously provided by Pall Corporation.

f. A new high capacity cooling system recirculating pump, associated fittings and hoses were purchased. Modification to the cooling systems reservoir was also made to accommodate this new pump.

After all these changes were accomplished, the test stand required approximately 8 gallons of test fluid to fill, the majority of it being in the heat exchangers and filters. During operation, approximately 7 gallons of fluid circulated. A schematic of the entire B-1 hydraulic pump test circuit is shown in Figure 2.

3.3 PUMP TESTS

The WL/MLBT hydraulic pump test stand is computer controlled with automatic shutdown interlocks. Data obtained during testing is presented digitally and simultaneously recorded on strip charts.

During these tests, pump stand start up was accomplished in the following manner. After proper pump test stand preparation, the pump depressurizing circuit was energized which allowed the drive motor and the pump speed to be increased at lower pump outlet pressures. After a few seconds and at around 5000 rpm, this circuit was de-energized allowing the outlet pressure to increase to normal levels. The speed was then increased to 5250 rpm, followed by a gradual increase of the output flow from the startup value of 3 gpm to 50 gpm. The pump inlet temperature was maintained at the desired value and the test continued for the entire 30 hour stage duration.

3.3.1 PUMP TESTS 33 AND 34

The MIL-H-5606F testing was conducted as outlined in Section II except that the pretest pump disassembly and inspection before the start of Stage I was not conducted. This pump was installed on the test stand in order to verify proper operation of the modified test stand. During this verification process, and filling the stand with fresh MIL-H-5606F, approximately 12 operating hours were accumulated on the pump, of which very few were at high flow rates or at high fluid temperature. It was then decided to continue using this pump for Test 33 without removing it from the stand for pretest inspection. During inspection after Stage I completion, a slight anomaly was observed on the rubbing surfaces of the piston shoes - radial erosion lines across the shoe faces. Unfortunately, since there was no pump inspection before the beginning of Stage I there is no way to determine if these lines were generated during pump stand operation verification, Stage I testing or were there to begin with. This condition did not seem to affect the performance of the pump. The subsequent pump inspections after Stage II and III revealed little or no change in the appearance of these lines. With the exception of these radial lines, the disassembly and inspection of the pump after each stage completion showed only slight polishing wear with no signs of loose material or debris. No evidence of cavitation on any pump parts was observed. Overall, the pump and the test fluid performed well during this test. No adjustments were made to the pump compensator before or during this test. Inspection of the patch filter after each stage completion revealed nothing unusual. No significant leaks were observed from the test stand. A total of about 500 ml of fluid leaked from the pump shaft seal. After completion of this test the great majority of the fluid was drained from the tubing, filter assemblies, reservoir and heat exchangers. Some of the tubing, the filter bowls and both large heat exchangers were removed from the stand and drained. The heat exchangers were partially disassembled to facilitate the draining process.

Pump Test 34 with MIL-H-87257 fluid was also conducted as outlined in Section II. Again, the pump and test fluid performed well. There were no discrepancies observed during pump inspections which were conducted after the completion of each stage. There were no signs of any loose material or debris, and only some slight polishing wear was observed on most rubbing surfaces. No evidence of cavitation on any pump part was observed. No adjustments were made to the pump compensator before or during this test. Inspection of the patch filter revealed nothing unusual. No significant leaks were observed from the test stand. A total of 115 ml of fluid leaked from the pump shaft seal.

Photographs of all critical pump parts and surfaces were taken during the pump inspections. These photos are presented in Appendix A and B. Detailed video movies were made during each disassembly and inspection, and are available for loan from WL/MLBT (point of contact: Shashi K. Sharma, at (937) 255-9029).

The pump case drain flow rates were observed and recorded during both pump tests. A comparison plot of the data is shown in Figure 3. It is interesting to note the case drain flow rates for the MIL-H-5606F fluid start out lower, but end up at a higher rate when compared to the flow rates for MIL-H-87257 fluid. This is attributed to the loss of viscosity of MIL-H-5606 with time due to its shear instability, discussed later.

The bleeding of air from the test stand was more difficult in the case of MIL-H-5606 as it seemed to retain more air than MIL-H-87257.

3.4 ANALYSIS OF FLUID SAMPLES

During the pump tests, fluid samples were extracted from the operating test stand as the testing progressed. These samples were taken at the approximate intervals listed in Section II. A number of different analyses were conducted on these samples.

The viscosities of the fluid samples taken were determined at 40 °C and 100 °C. These viscosities are compared in Figure 4. It is easily seen that MIL-H-5606F suffered significant viscosity losses during the first 30 hours of pump testing, whereas the viscosity of MIL-H-87257 was very stable throughout the test. The viscosity index (VI) improvers used to boost the viscosity of MIL-H-5606, break-up under the high shear environment inside the pump, causing a permanent loss of the fluid viscosity. Under the high pressure and high shear rate environment, the VI improved fluids behave more like the base oil (Reference 1).

Water content and acid numbers of the fluid samples were determined and are shown in Table 1.

Trace metal analysis was also performed on these fluid samples. The samples were analyzed for 19 elements including Fe, Ag, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, B, Ba, Cd, Mn, Mo, V, and Z. Only those elements which show concentrations above 0.1 ppm. are reported in Table 2.

Samples taken at the end of each stage of testing and the fresh samples of each of the test fluids were evaluated for lubricity. These evaluations were accomplished by 4-ball wear testing method (ASTM D-

4172). The results of the lubricity tests are shown in Figure 5. Clearly, these data indicate better lubricity for MIL-H-87257 when compared to MIL-H-5606F.

4.0 CONCLUSIONS

4.1 MIL-H-5606 and MIL-H-87257 hydraulic fluids were successfully pump tested in B-1 aircraft hydraulic pumps under identical conditions. Both pumps showed only slight polishing wear with the exception of the appearance of radial lines on the piston shoe faces of the pump tested with MIL-H-5606. It could not be concluded whether these lines appeared during the testing, or existed prior to the test. However, these lines did not seem to affect the functioning of the pump, and also did not grow in size during the test. No cavitation on any pump parts was observed for both tests.

4.2 MIL-H-87257 exhibited better lubricity than MIL-H-5606, as determined by the ASTM D-4172 four-ball wear tests.

4.3 Viscosity of MIL-H-5606 reduced by 50% during the first 30 hours of testing.

4.4 MIL-H-5606 seems to retain more air than MIL-H-87257.

4.5 MIL-H-87257 has exhibited equivalent or better performance than MIL-H-5606 in the B-1 hydraulic pump tests.

5.0 REFERENCES

1. Sharma, S.K. and Forster, N.H., and Gschwender, L.J., "Effect of Viscosity Index Improvers on the Elastohydrodynamic Lubrication Characteristics of a Chlorotrifluoroethylene and a Polyalphaolefin Fluid," Tribology Transactions, vol. 36, no. 3, pp 555-564, Oct 1993

6.0 FIGURES

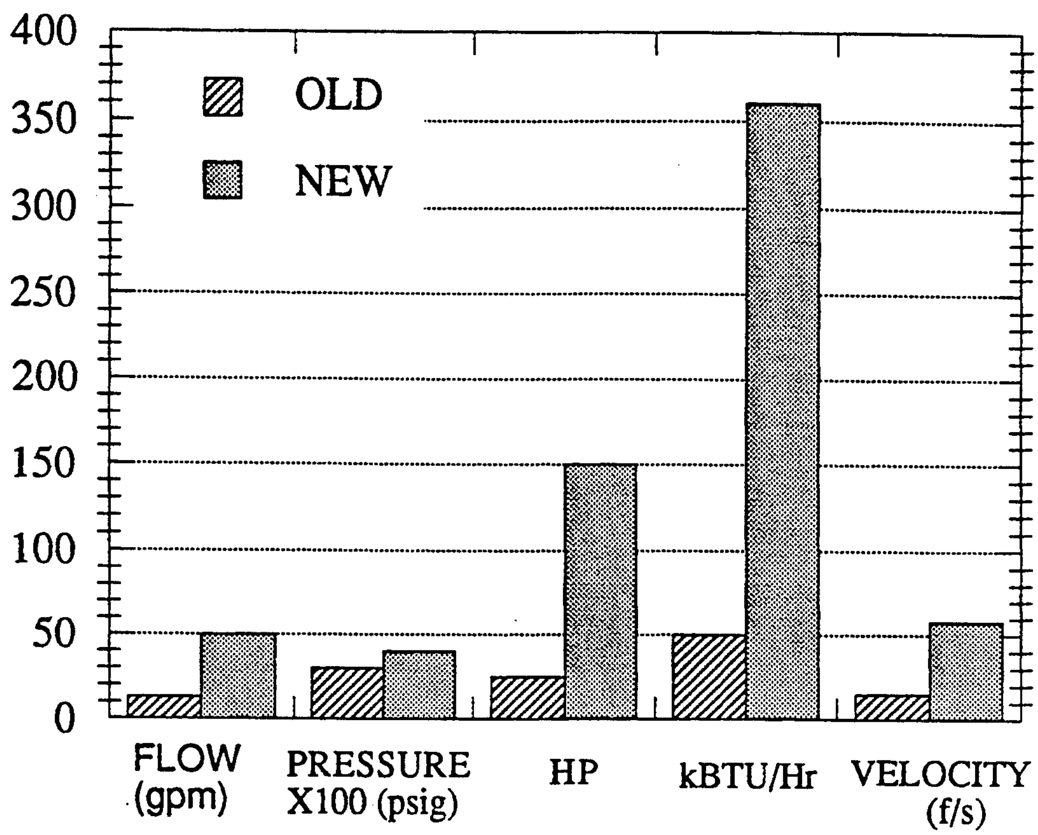


Figure 1. Hydraulic Pump Test Stand Configurations

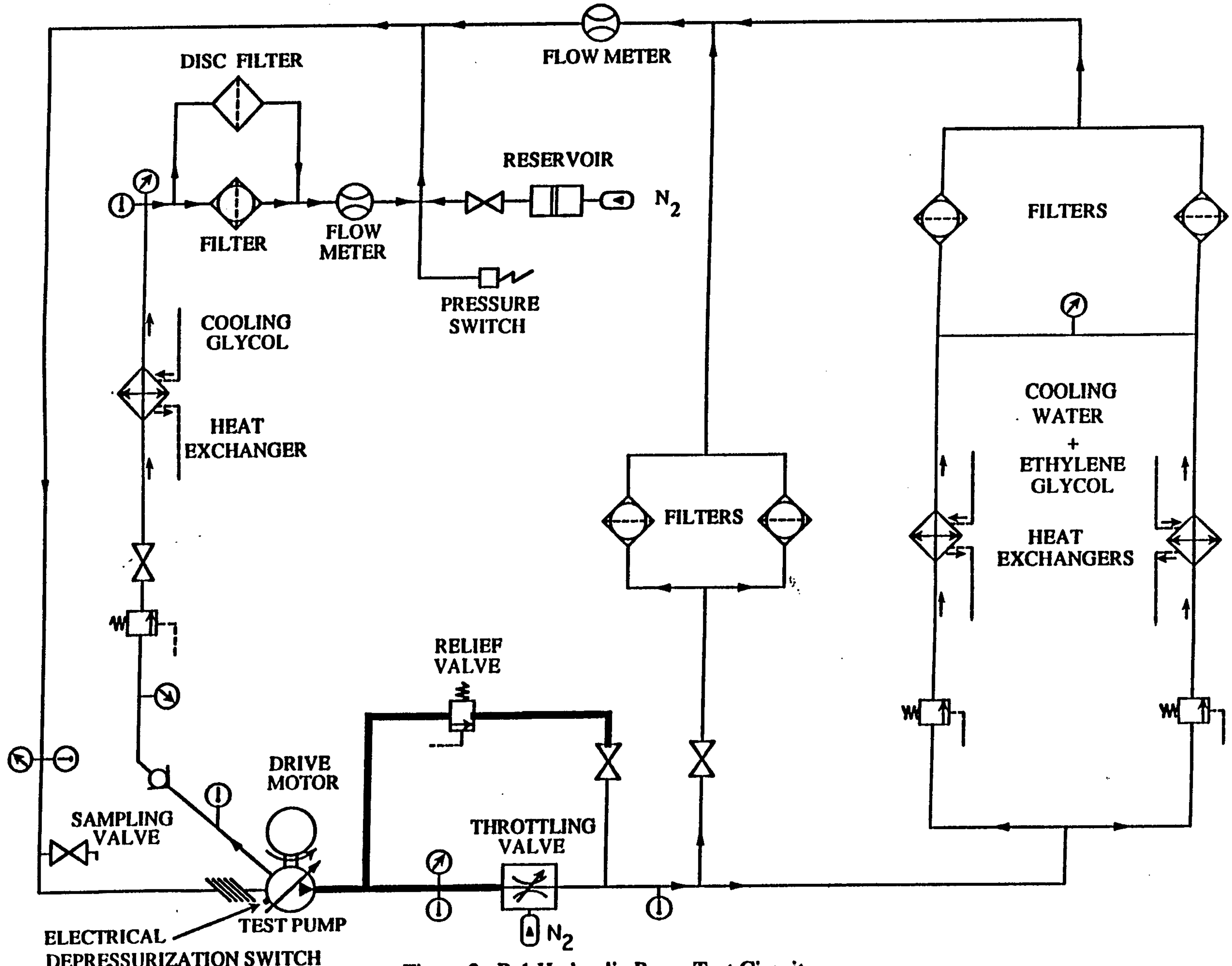


Figure 2. B-1 Hydraulic Pump Test Circuit

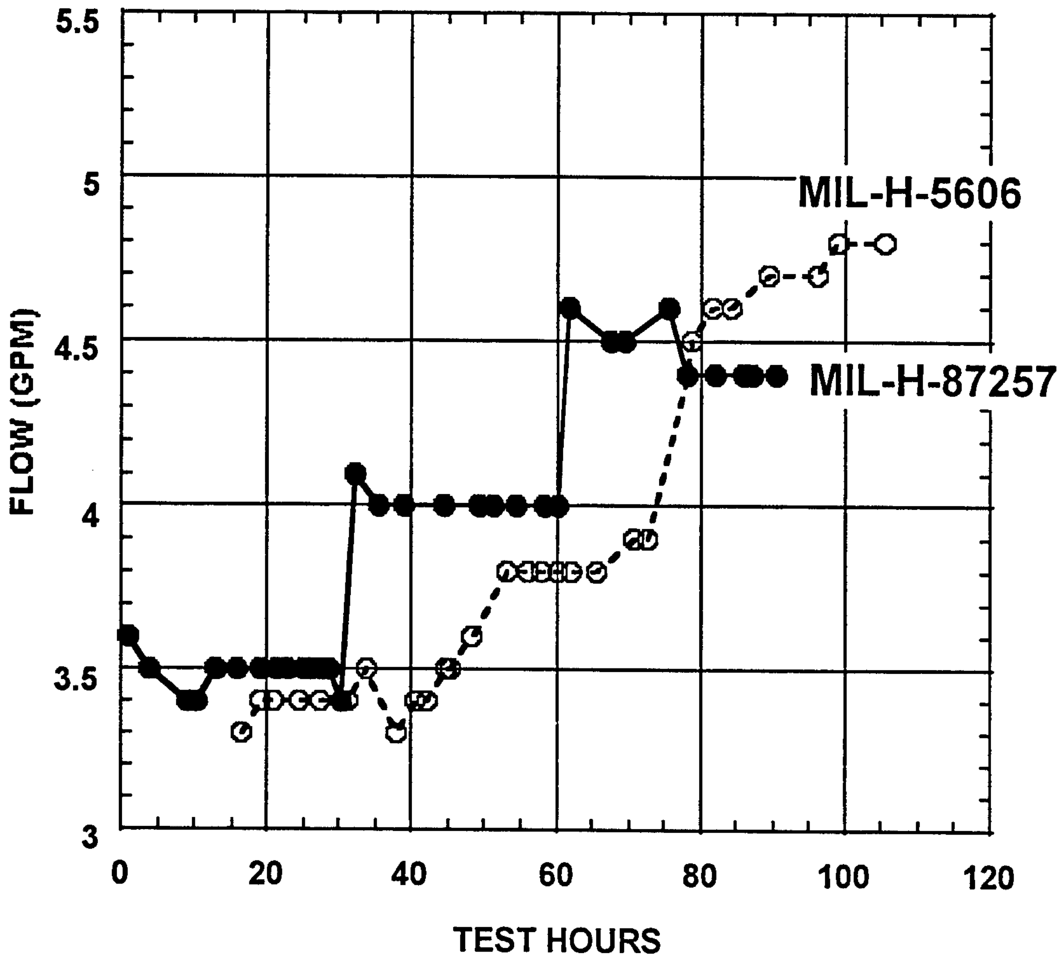


Figure 3. Case drain flow in B-1 pump tests

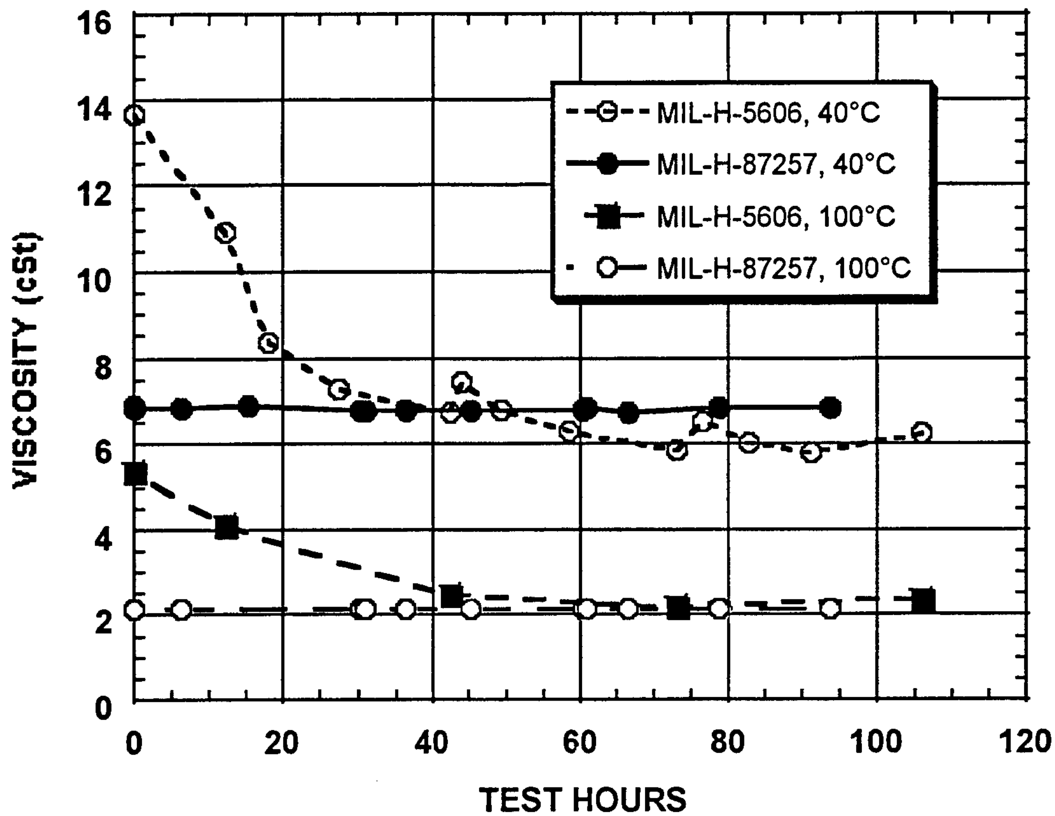


Figure 4. Viscosity change in B-1 pump tests

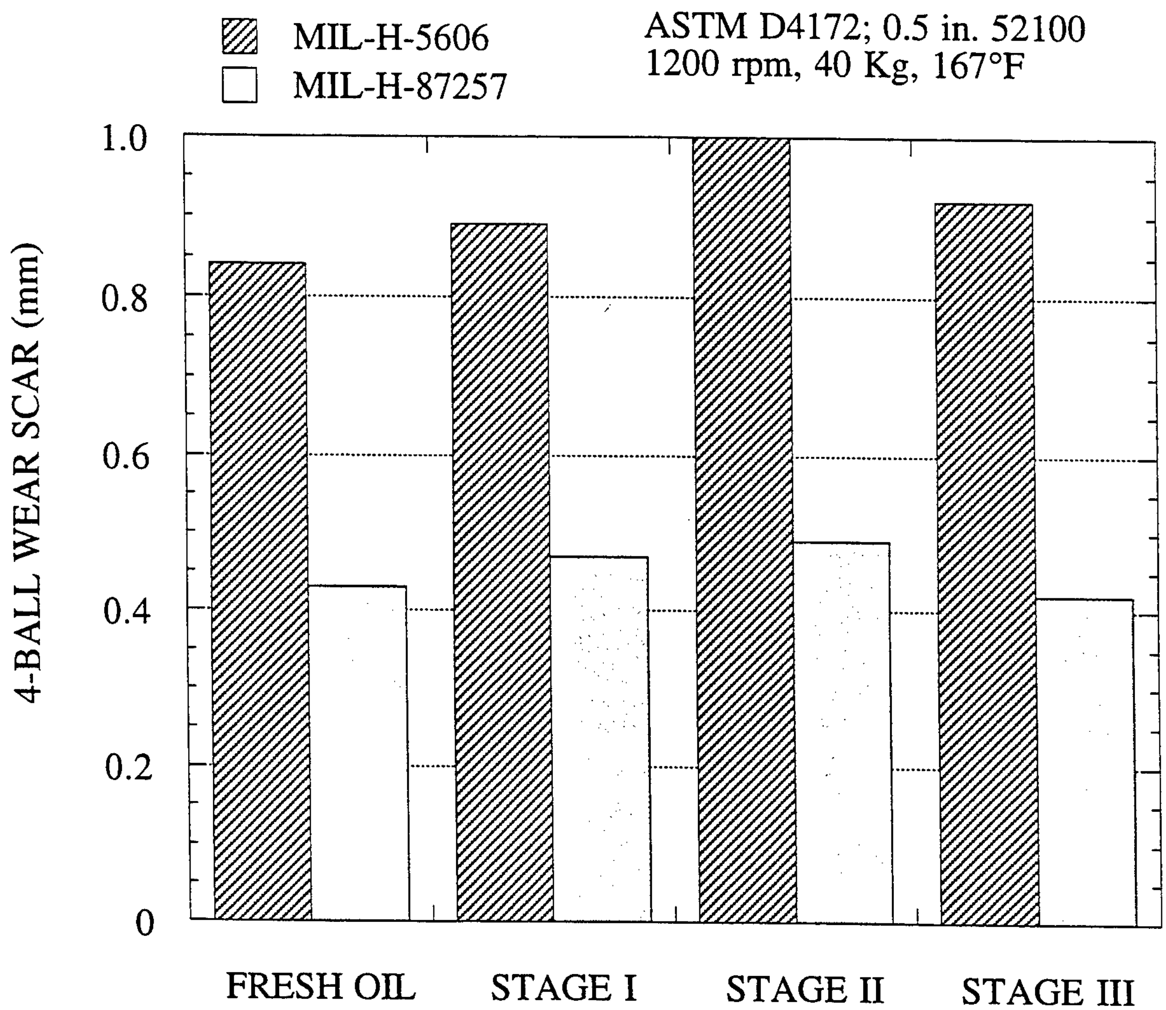


Figure 5. Four-Ball Wear Scar with B-1 Pump Test Fluid Samples

7.0 TABLES

TABLE 1. WATER CONTENT AND ACID NUMBERS OF MIL-H-5606F

SAMPLE NUMBER	TOTAL HOURS	STAGE HOURS	WATER (ppm)	ACID NO. (mgKOH/gm)
STAGE-I				
FRESH FLUID	0.0	0.0	56	0.00
MLO 93-1	12.2	0.2	55	0.00
MLO 93-2	18.0	6.0	57	*
MLO 93-3	27.5	15.5	*	*
MLO 93-4	42.5	30.0	94	0.00
STAGE-II				
MLO 93-5	44.2	1.0	89	0.00
MLO 93-6	49.5	6.3	*	*
MLO 93-7	58.3	15.1	*	*
MLO 93-8	73.2	30.0	116	0.08
STAGE-III				
MLO 93-9	76.6	0.2	92	0.00
MLO 93-10	82.7	6.0	*	*
MLO 93-11	91.4	15.0	*	*
MLO 93-12	106.0	29.6	90	0.00
MLO 93-13 (case line)	106.0	29.6	116	0.00
MLO 93-14 (pump case)	106.0	29.6	97	*

* data not determined

WATER CONTENT AND ACID NUMBERS OF MIL-H-87257

SAMPLE NUMBER	TOTAL HOURS	STAGE HOURS	WATER (ppm)	ACID NO. (mgKOH/gm)
STAGE-I				
FRESH FLUID	0.0	0.0	85	0.04
MLO 93-66	0.1	0.1	127	0.00
MLO 93-15	6.1	6.1	172	*
MLO 93-16	15.3	15.3	169	*
MLO 93-67	30.3	30.3	168	*
STAGE-II				
MLO 93-68	30.8	0.5	166	0.00
MLO 93-69	36.3	6.0	*	*
MLO 93-70	45.4	15.1	*	*
MLO 93-71	60.3	30.0	173	0.00
STAGE-III				
MLO 93-72	60.9	0.6	165	0.00
MLO 93-73	66.7	6.0	*	*
MLO 93-74	78.8	15.0	*	*
MLO 93-75	93.8	30.0	154	0.00

* data not determined

Table 2. Trace Metal Analysis of Pump Test Fluid Samples

Test 33 with MIL-H-5606F

Sample Number	Total Hours	Stage Hours	Fe (ppm)	Ba (ppm)
Stage I				
MLO 93-1	12.2	0.2	0.00	1.7
MLO 93-2	18.0	6.0	0.12	1.9
MLO 93-3	27.5	15.5	0.16	1.9
MLO 93-4	42.5	30.0	0.26	2.0
Stage II				
MLO 93-5	44.2	1.0	0.22	1.5
MLO 93-6	49.5	6.3	0.26	1.7
MLO 93-7	58.3	15.1	0.31	1.8
MLO 93-8	73.2	30.0	0.39	1.8
Stage III				
MLO 93-9	76.6	0.2	0.27	1.5
MLO 93-10	82.7	6.0	0.32	1.5
MLO 93-11	91.4	15.0	0.33	1.6
MLO 93-12	106.0	29.6	0.35	1.5
MLO 93-13 (case line)	106.0	29.6	0.41	1.5
MLO 93-14 (pump case)	106.0	29.6	0.49	1.6

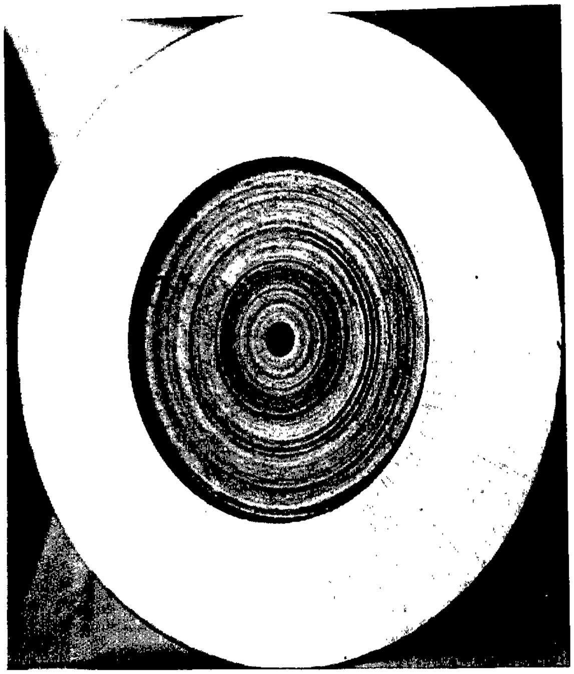
Test 34 with MIL-H-87257

Sample Number	Total Hours	Stage Hours	Fe (ppm)	Ba (ppm)
Stage I				
MLO 93-66	0.1	0.1	0.13	3.1
MLO 93-15	6.1	6.1	0.02	2.4
MLO 93-16	15.3	15.3	0.04	2.3
MLO 93-67	30.3	30.3	0.05	2.3
Stage II				
MLO 93-68	30.8	0.5	0.04	2.3
MLO 93-69	36.3	6.0	0.05	2.2
MLO 93-70	45.4	15.1	0.05	2.2
MLO 93-71	60.3	30.0	0.06	2.1
Stage III				
MLO 93-72	60.9	0.6	0.07	2.1
MLO 93-73	66.7	6.0	0.07	1.9
MLO 93-74	78.8	15.0	0.06	1.9
MLO 93-75	93.8	30.0	0.08	1.6

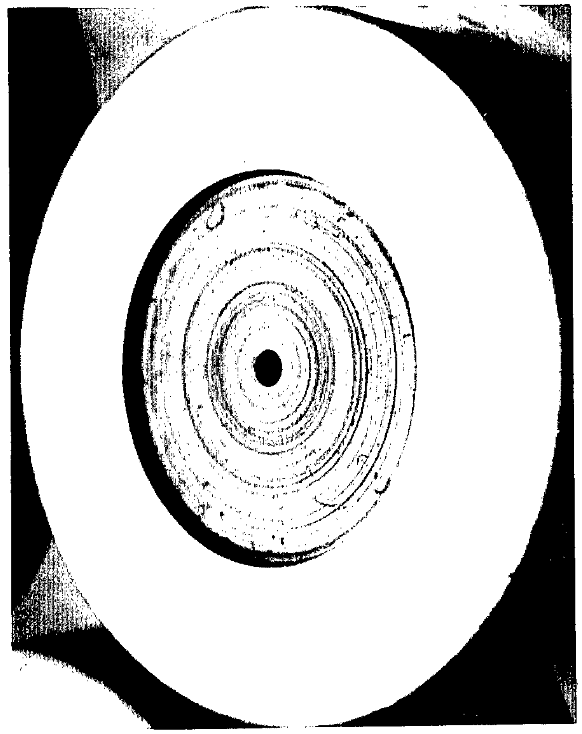
Appendix A

Inspection Photographs from

Pump Test 33, MIL-H-5606F



Stage I



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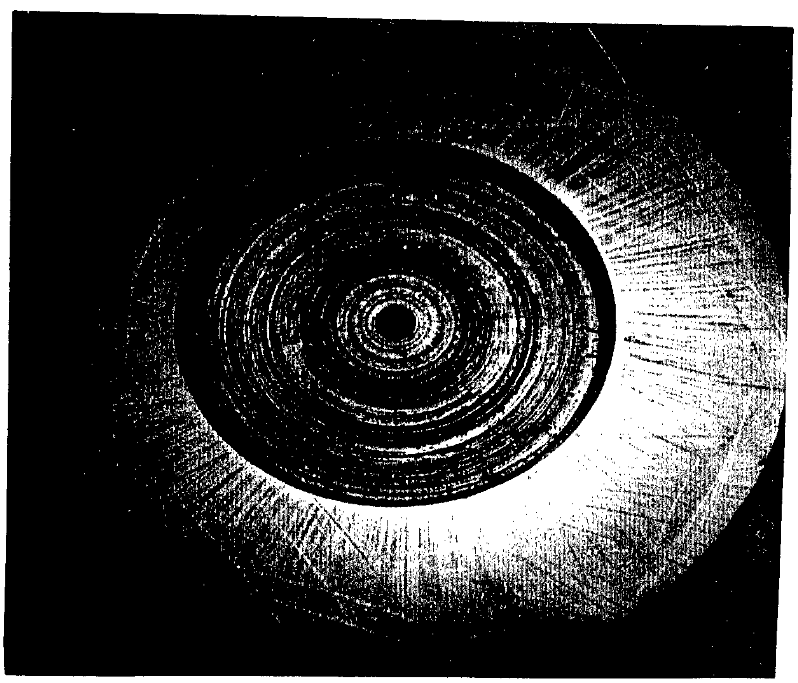
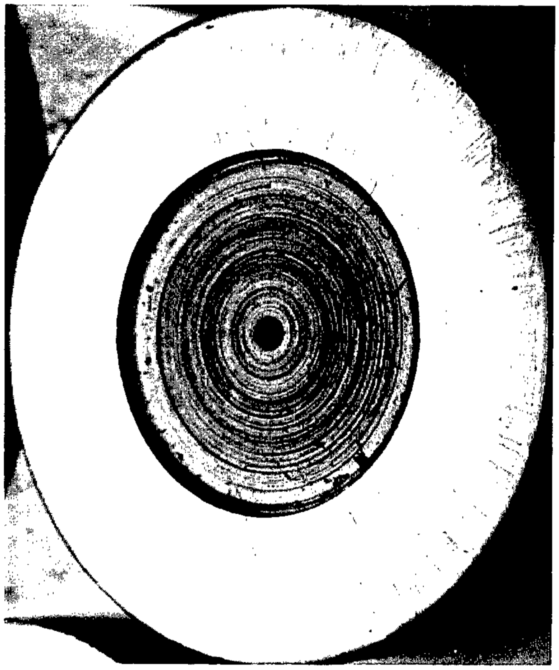


Stage III

Piston 1 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



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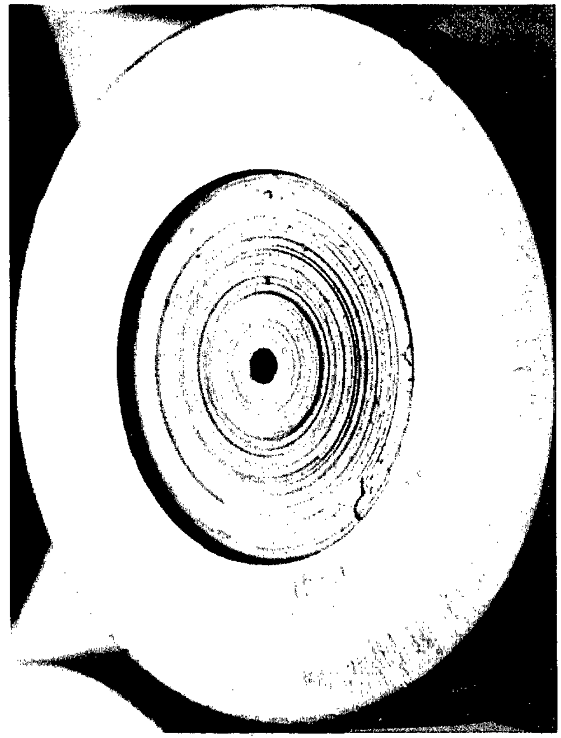

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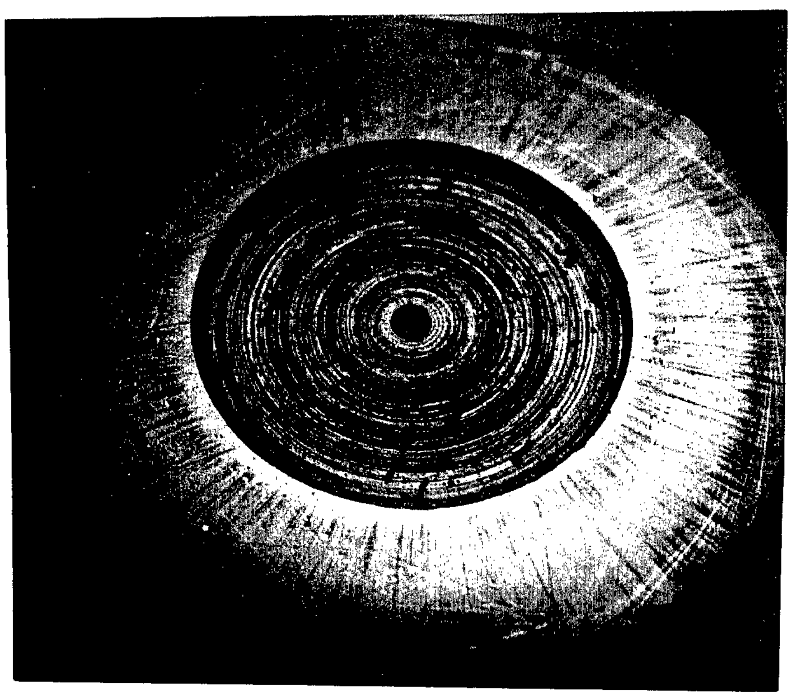
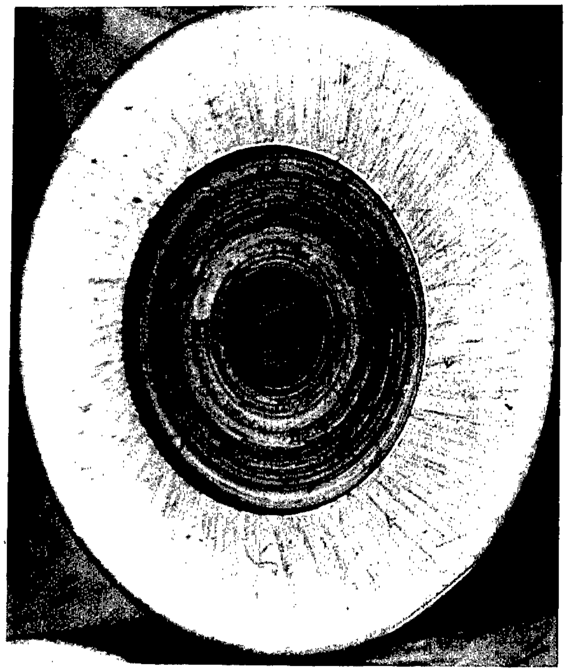


Stage III

Piston 2 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



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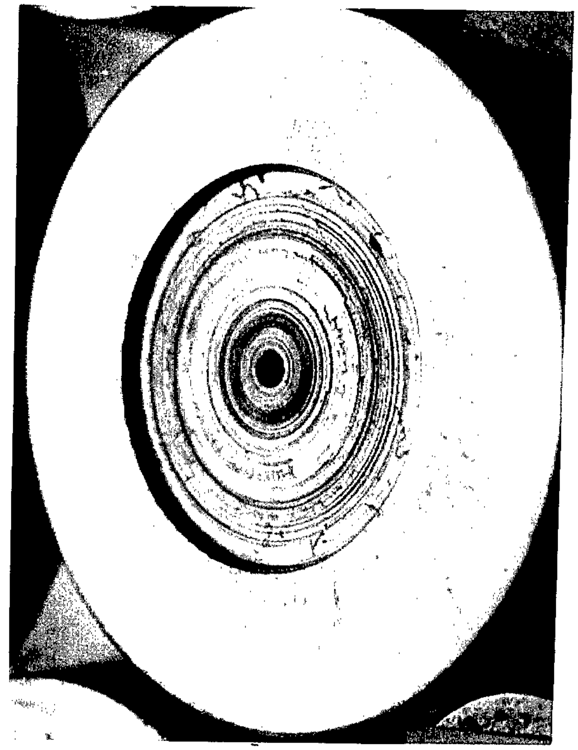

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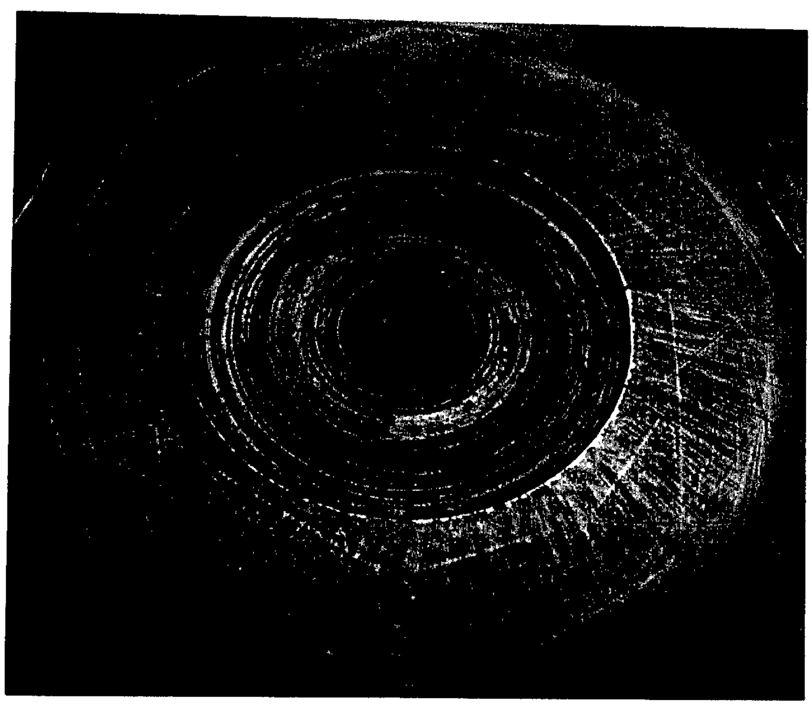
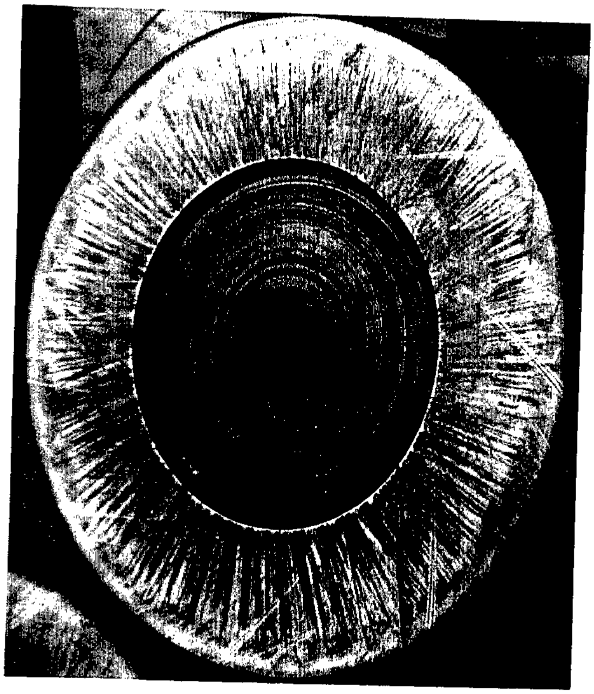


Stage III

Piston 3 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



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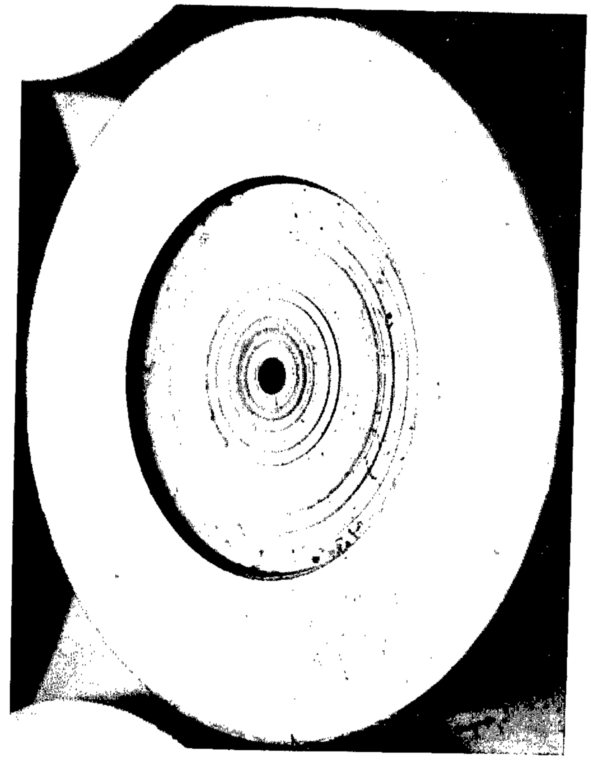

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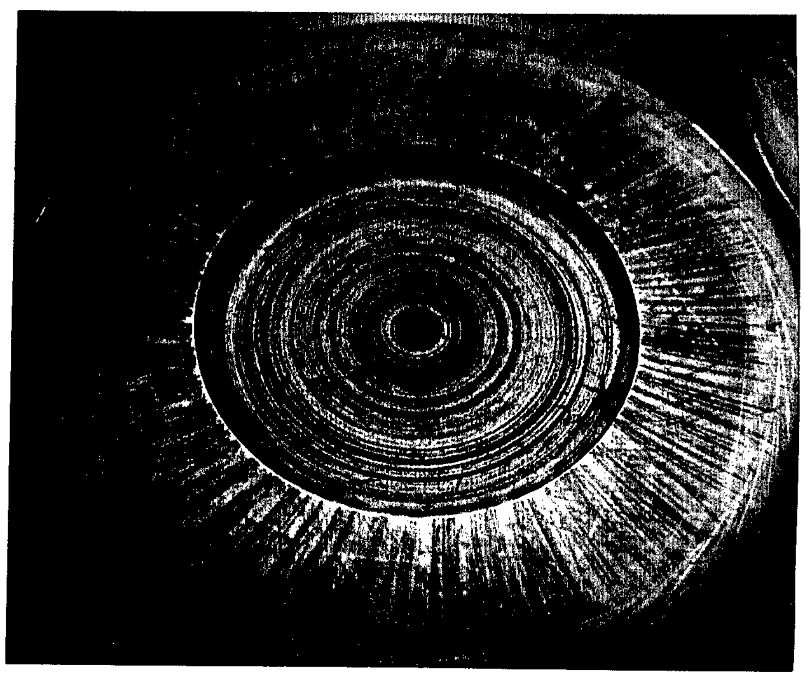
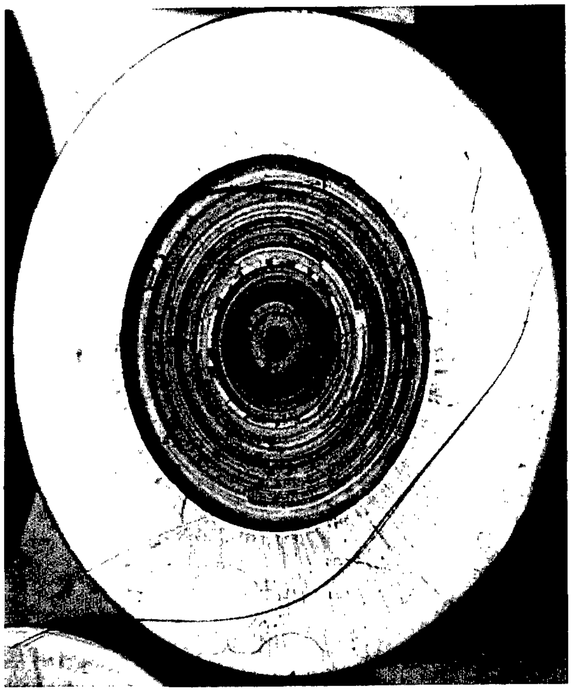
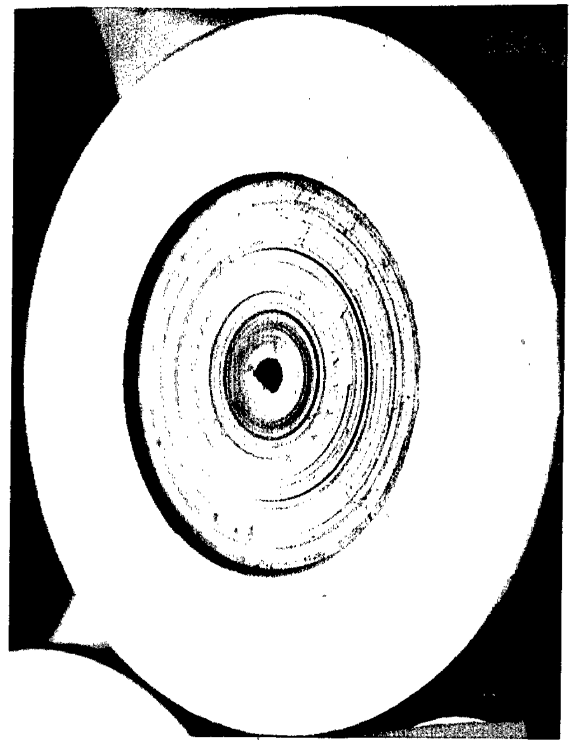


Stage III

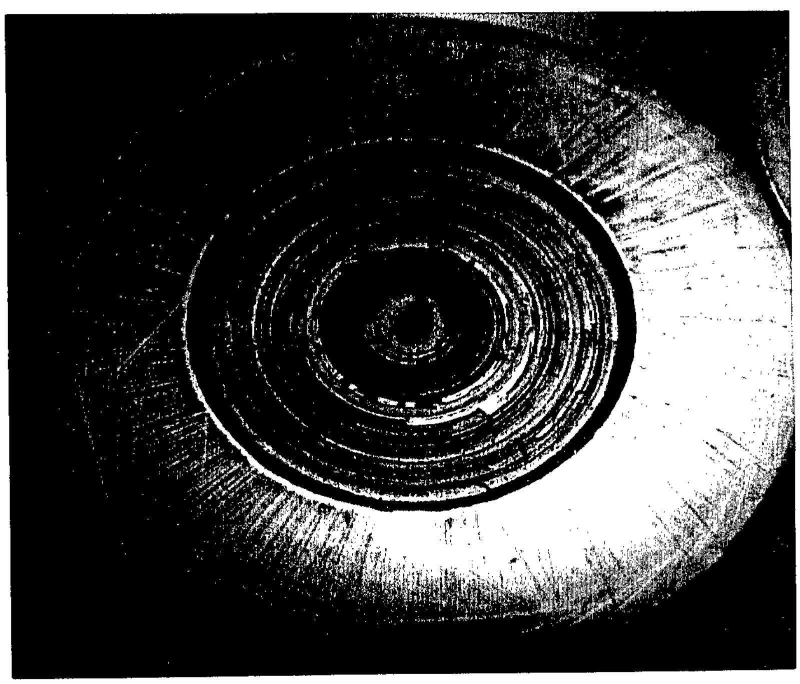
Piston 4 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



Stage I

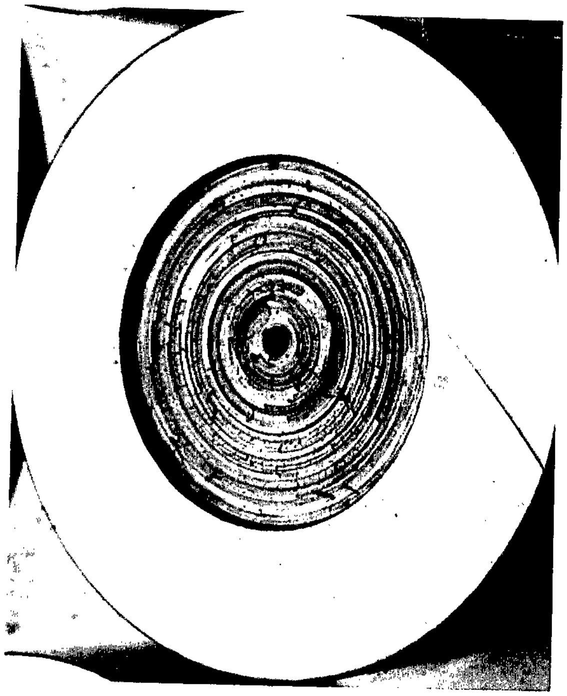


Stage II

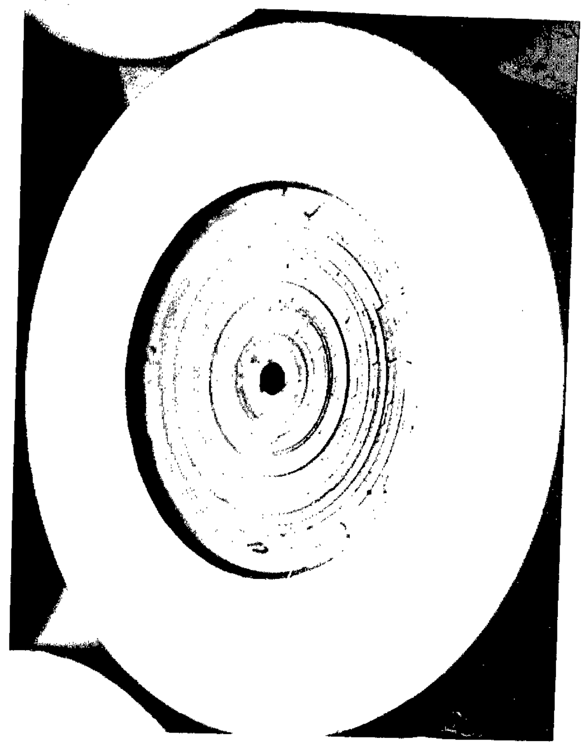


Stage III

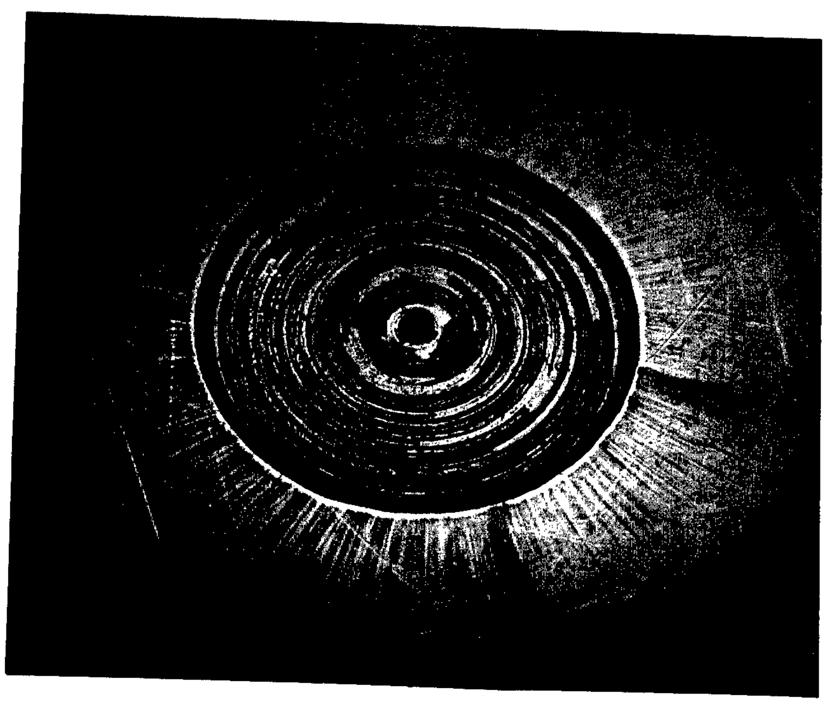
Piston 5 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



Stage I

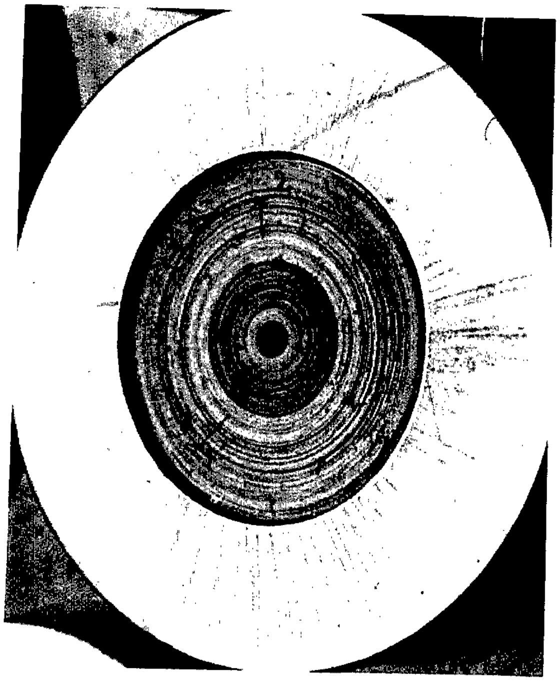


Stage II

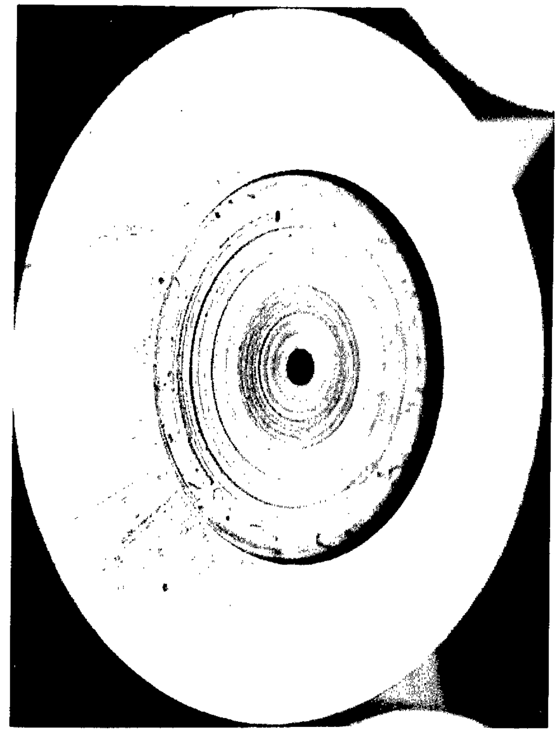


Stage III

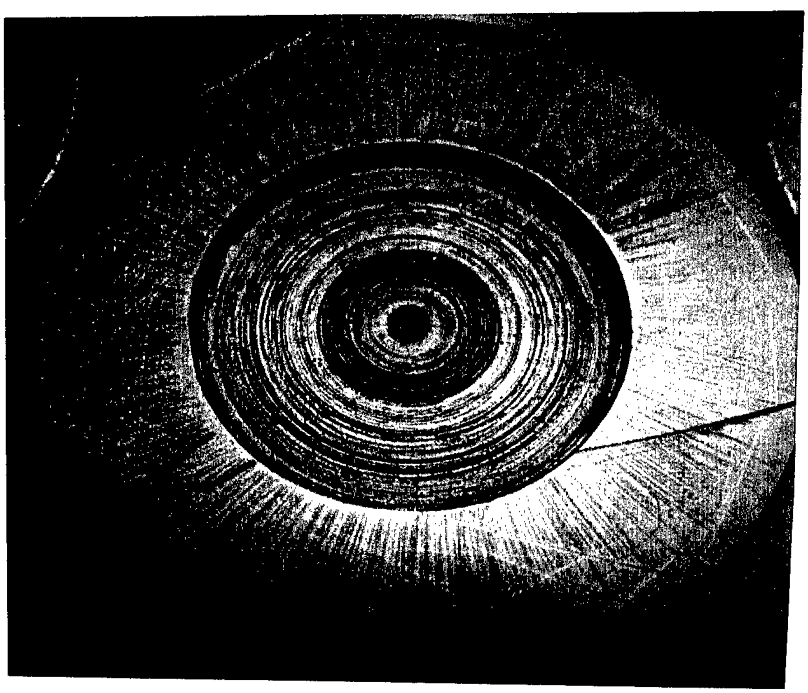
Piston 6 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



Stage I

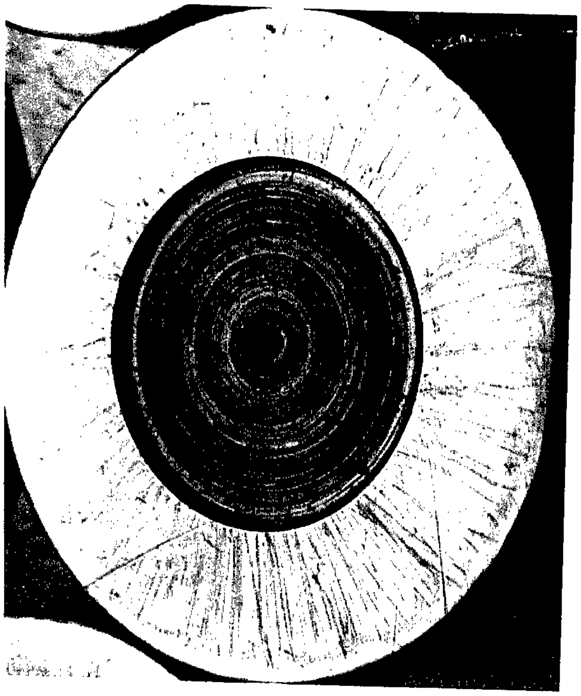


Stage II

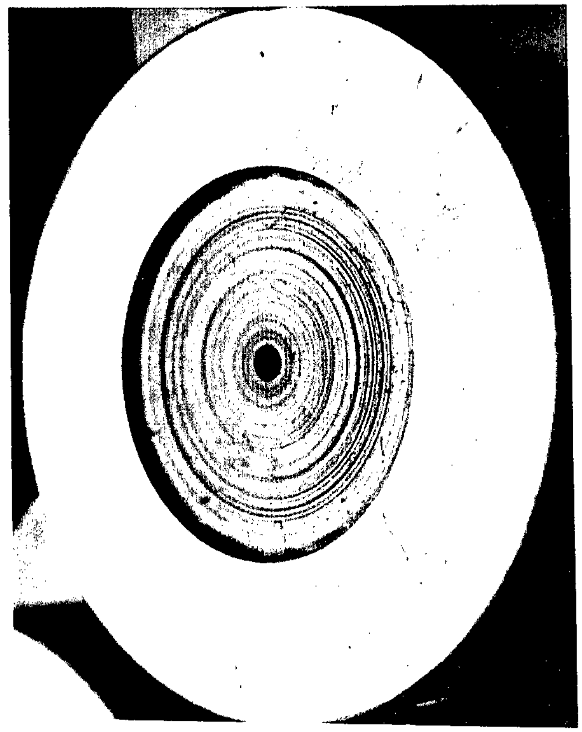


Stage III

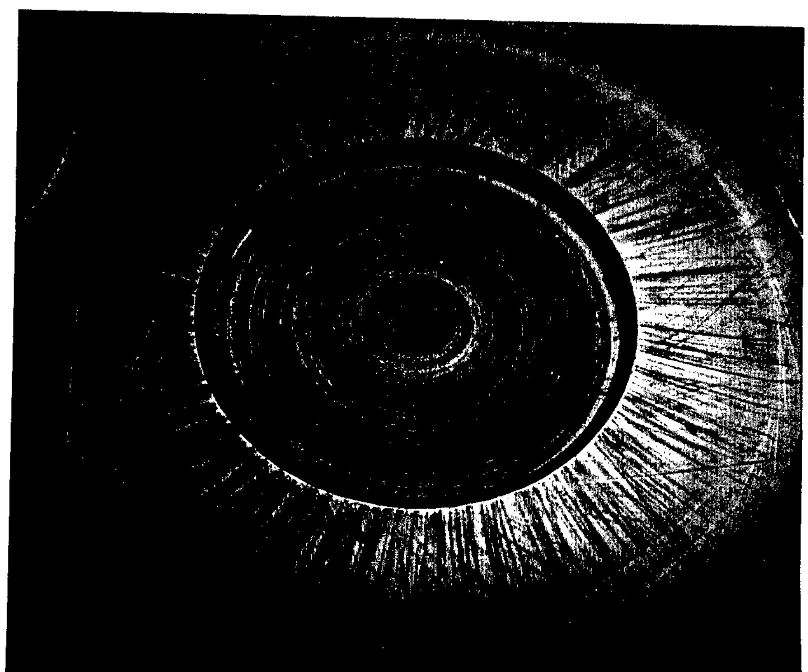
Piston 7 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



Stage I

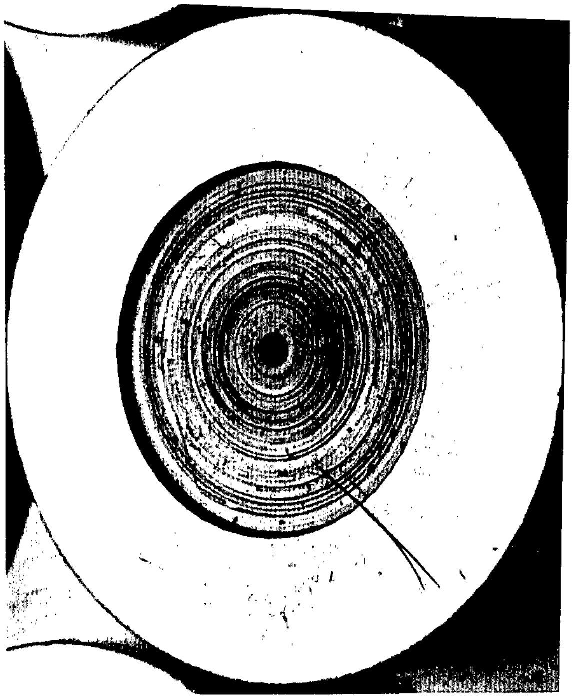


Stage II

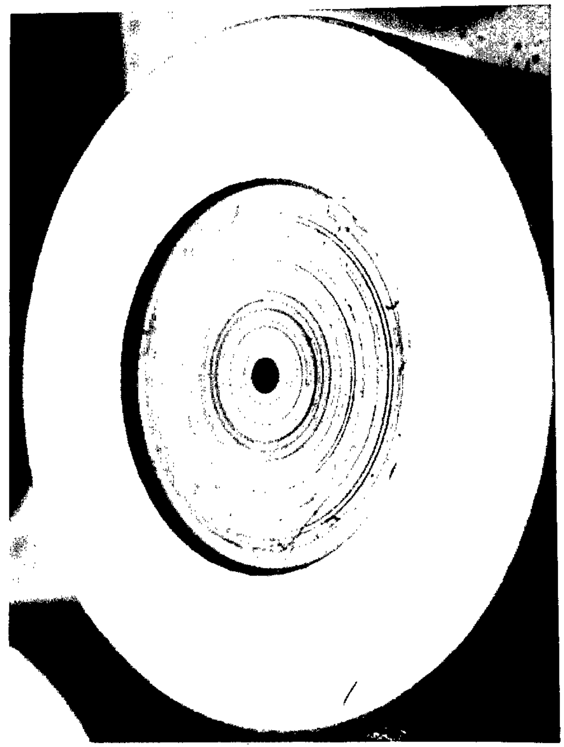


Stage III

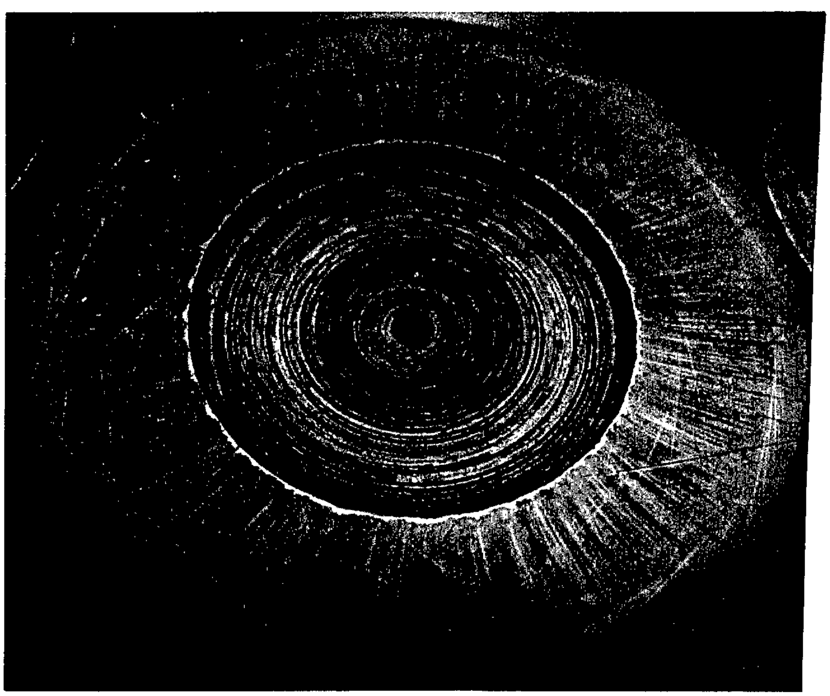
Piston 8 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



Stage I

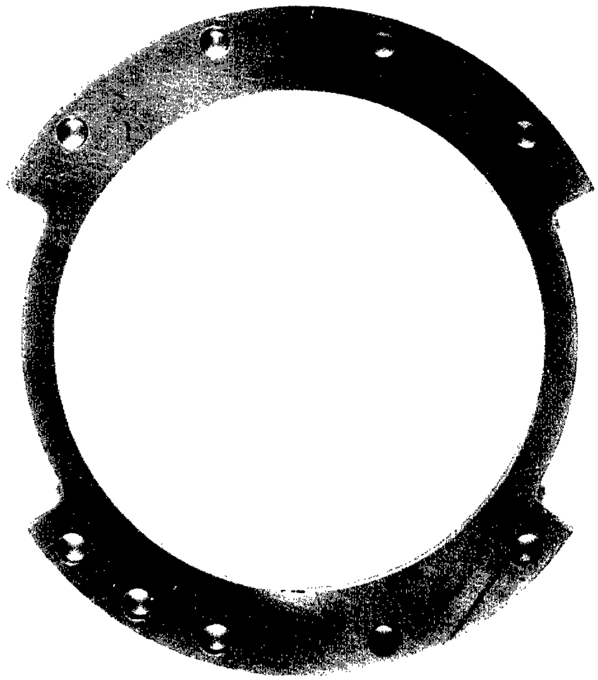


Stage II



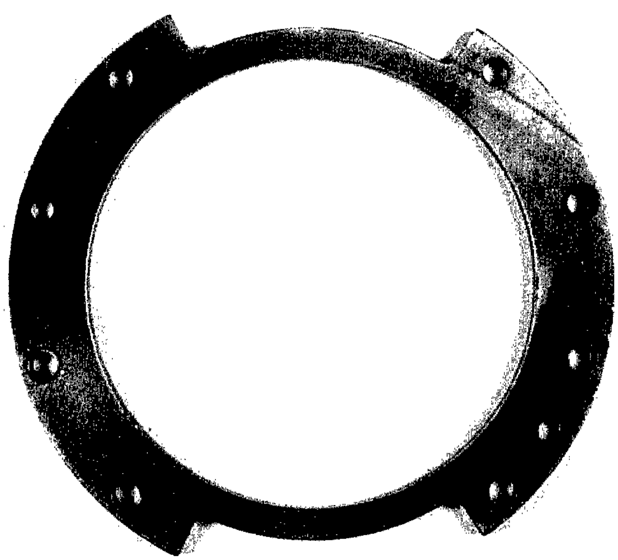
Stage III

Piston 9 Shoe Face After Stages I, II, and III
Pump Test 33 with MIL-H-5606F



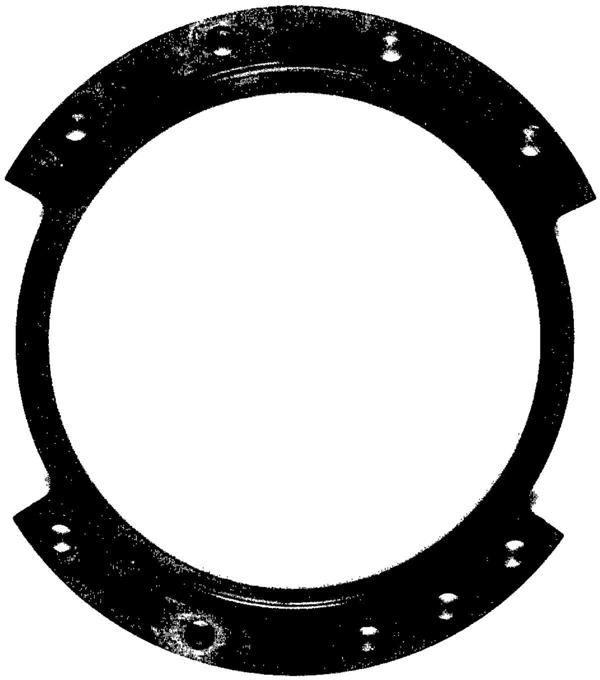
Stage I

Stage II

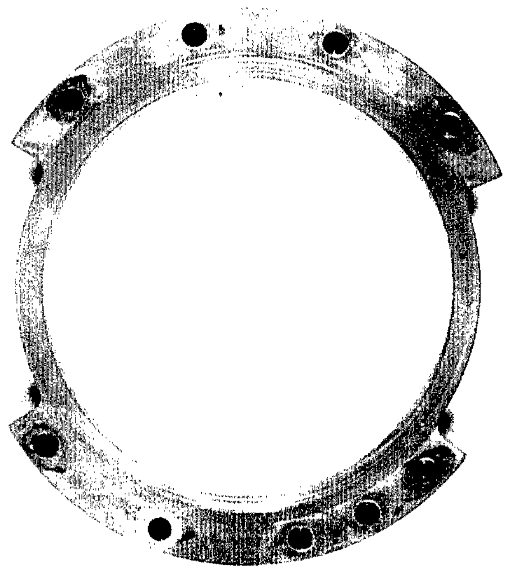


Stage III

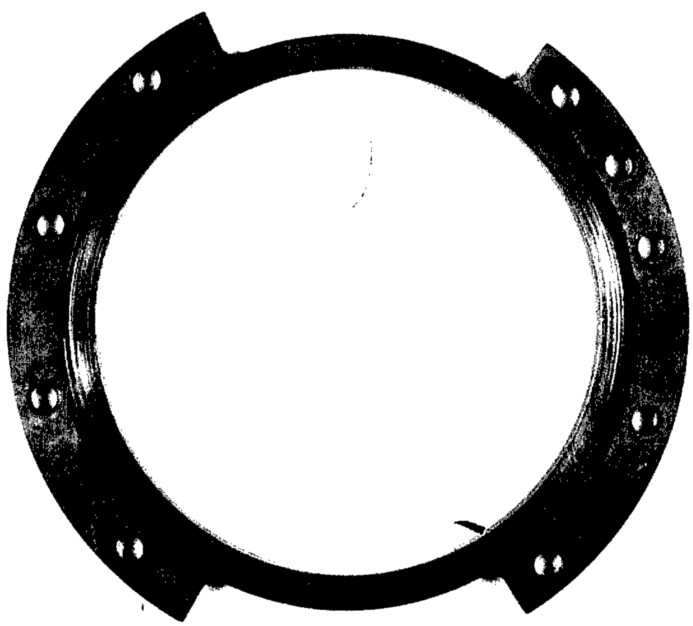
Hold Down Plate - Non Rubbing Side after Stage I, II and III
Pump Test 33 with MIL-H-5606F



Stage I

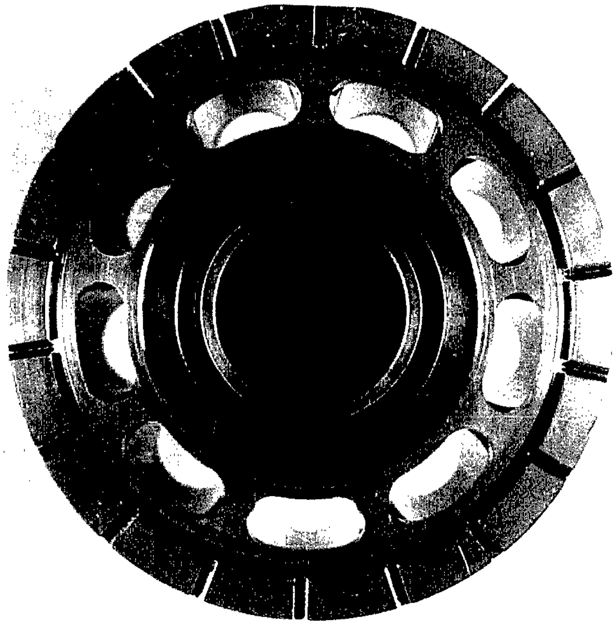


Stage II

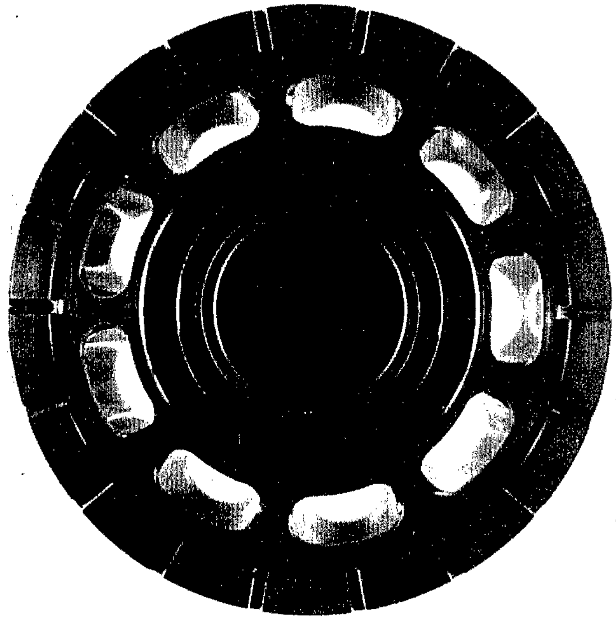


Stage III

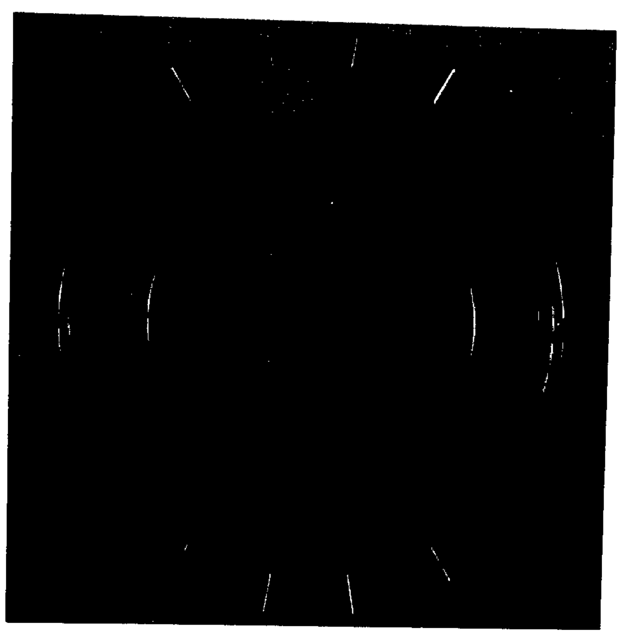
Hold Down Plate - Rubbing Side after Stage I, II and III
Pump Test 33 with MIL-H-5606F



Stage I

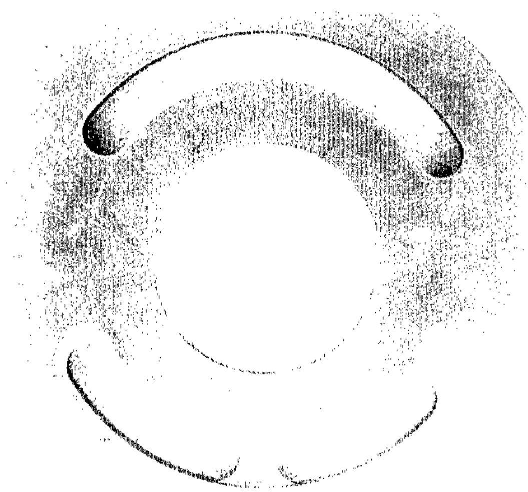


Stage II



Stage III

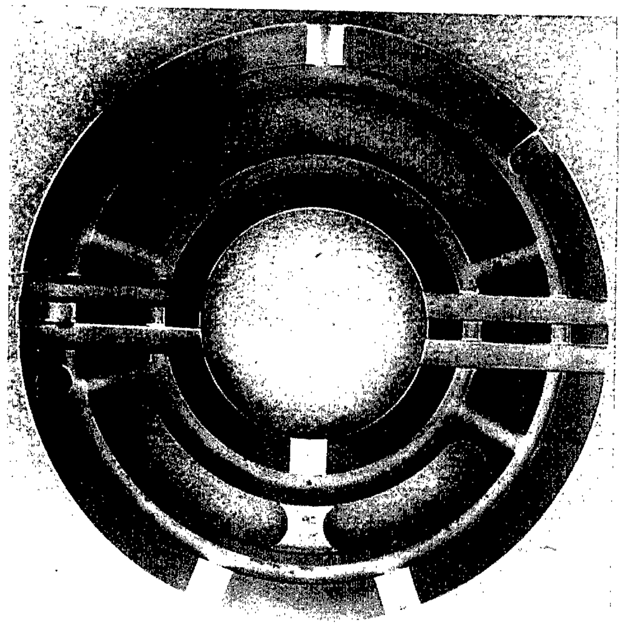
Cylinder Block Face after Stage I, II and III
Pump Test 33 with MIL-H-5606F



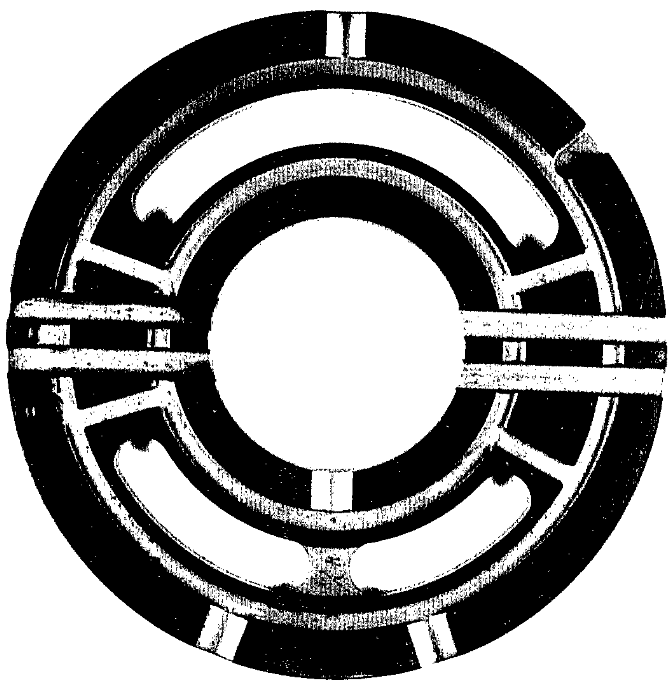
Stage II

Stage III

Waffle Plate - Rubbing Side after Stage II and III
Pump Test 33 with MIL-H-5606F

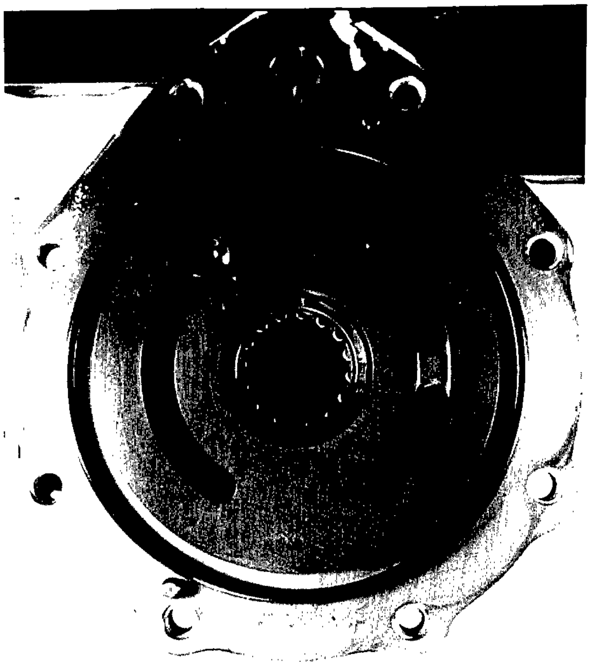


Stage II

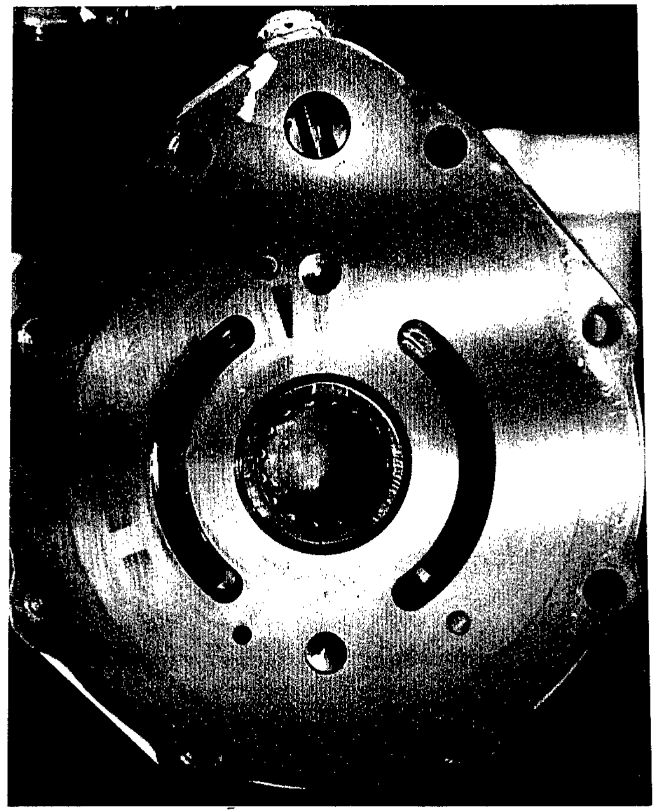


Stage III

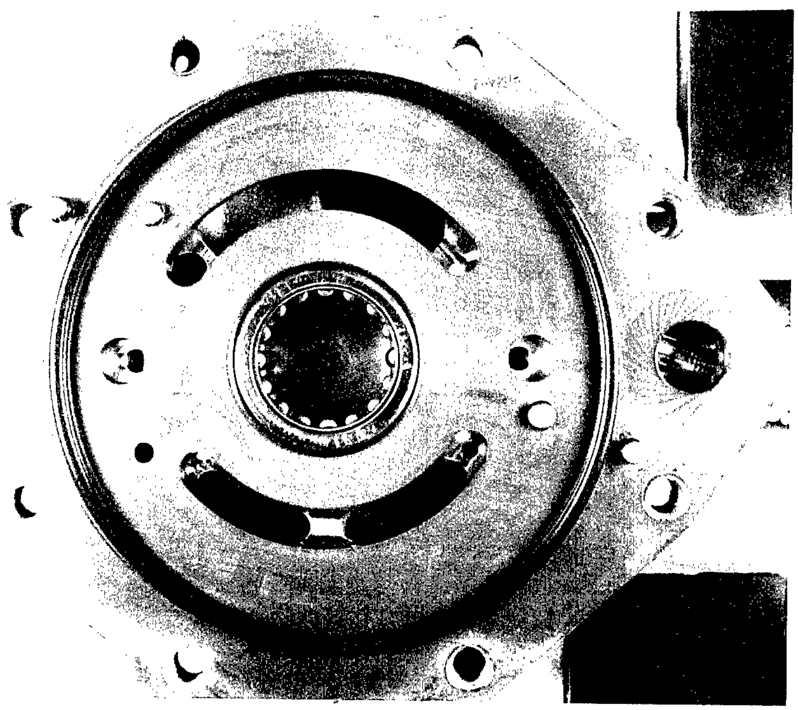
Waffle Plate - Non Rubbing Side after Stage II and III
Pump Test 33 with MIL-H-5606F



Stage I

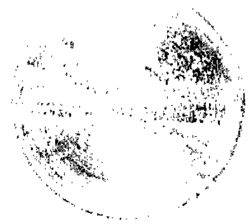


Stage II

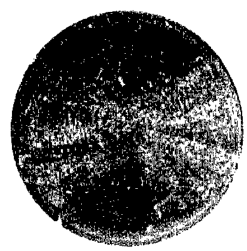


Stage III

Cylinder Block Plate after Stage I, II and III
Pump Test 33 with MIL-H-5606F



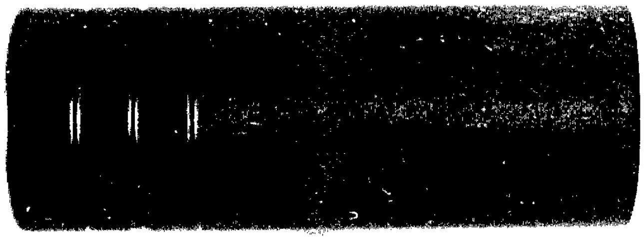
Stage I



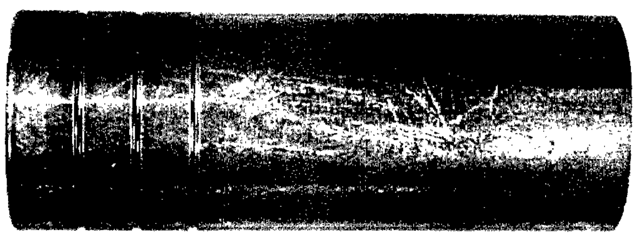
Stage II

Stage III

Actuator Piston - Front View after Stage I, II and III
Pump Test 33 with MIL-H-5606F

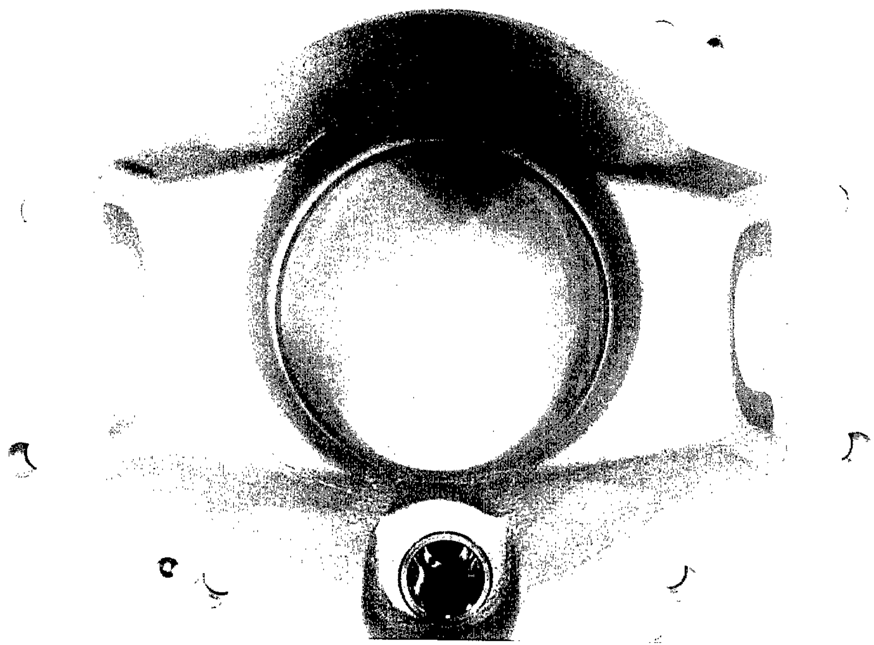


Stage II

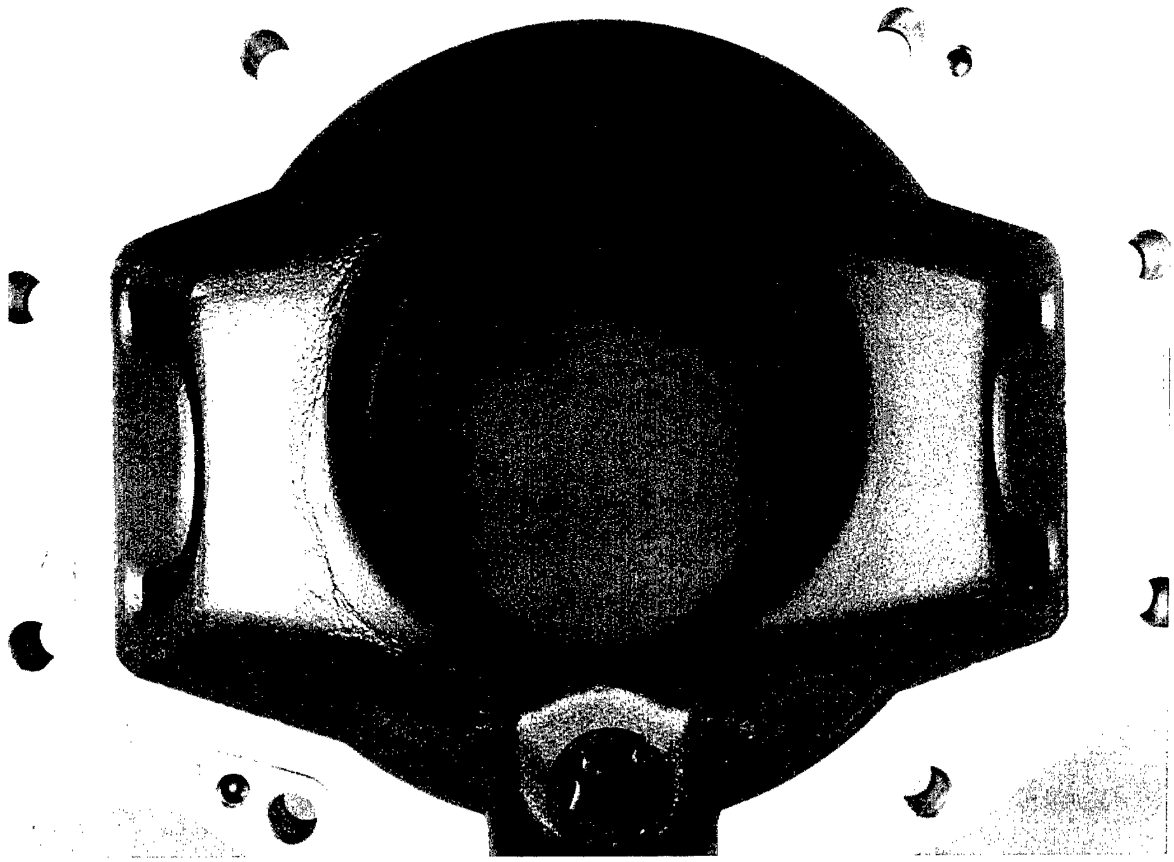


Stage III

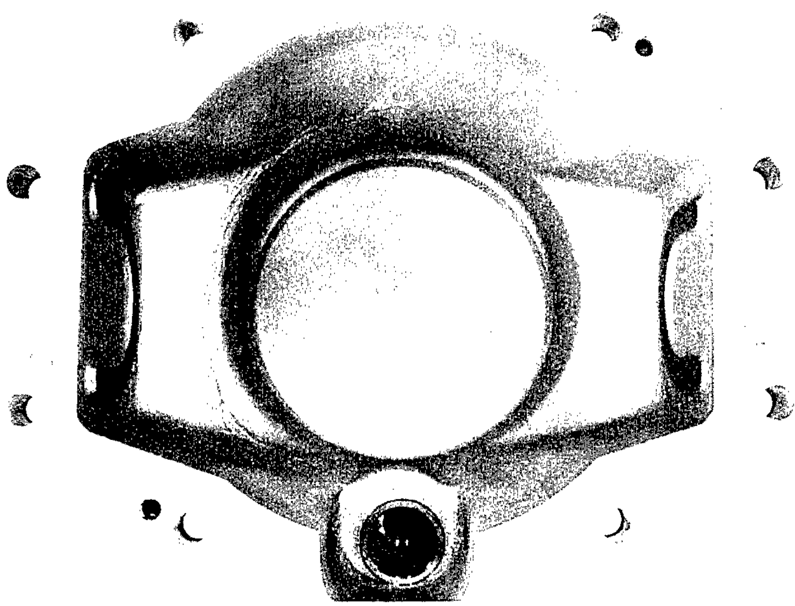
Actuator Piston -Side view after Stage II and III
Pump Test 33 with MIL-H-5606F



Housing after Stage I
Pump Test 33 with MIL-H-5606F

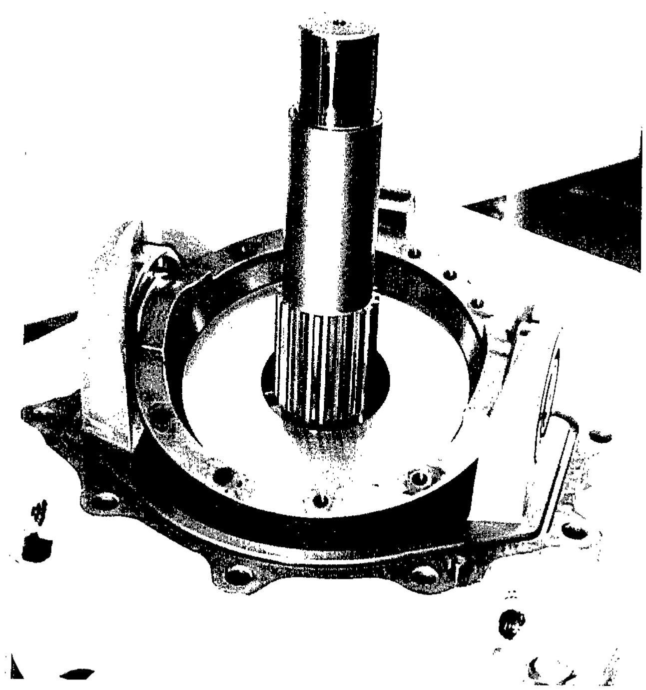


Stage II



Stage III

Housing after Stage II and III
Pump Test 33 with MIL-H-5606F



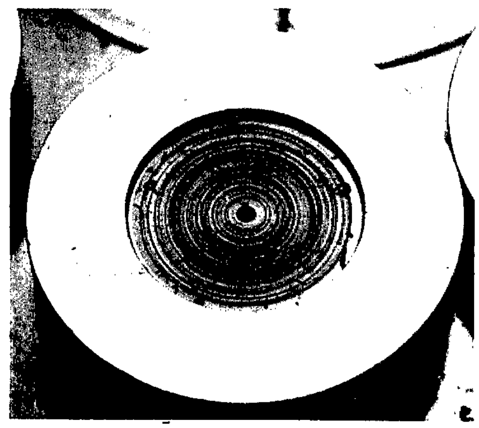
Partial Assembly of Test Pump after Stage II
Pump Test 33 with MIL-H-5606F

Appendix B

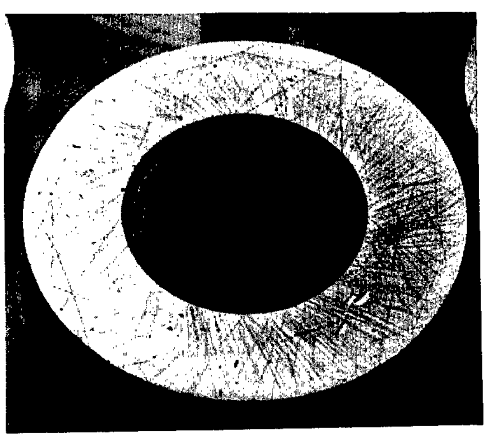
Inspection Photographs from

Pump Test 34, MIL-H-87257

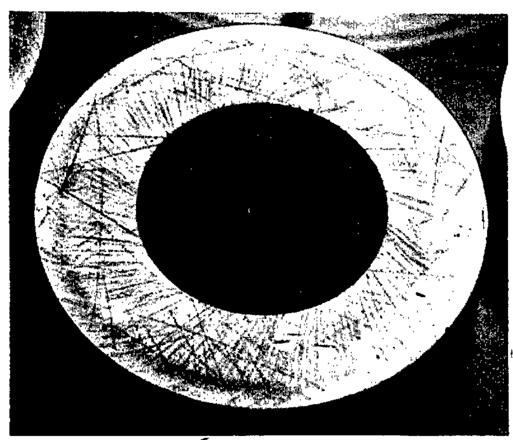
Pretest



Stage I

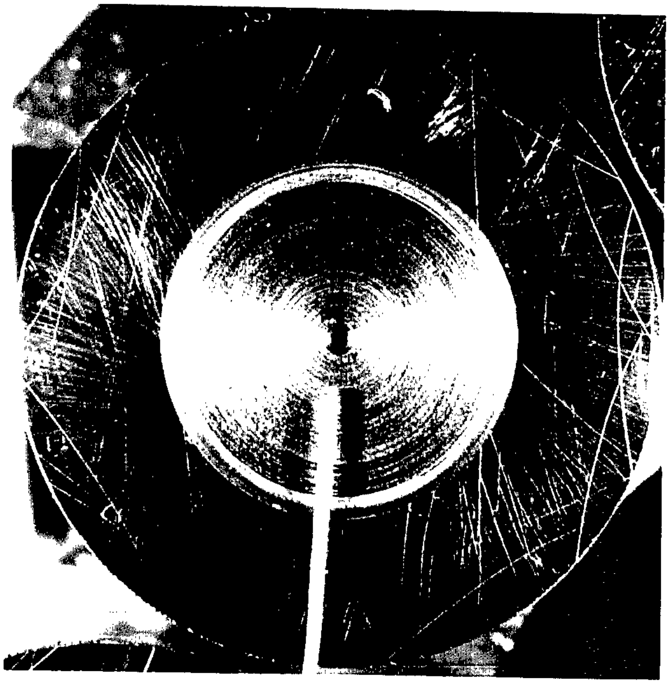


Stage II

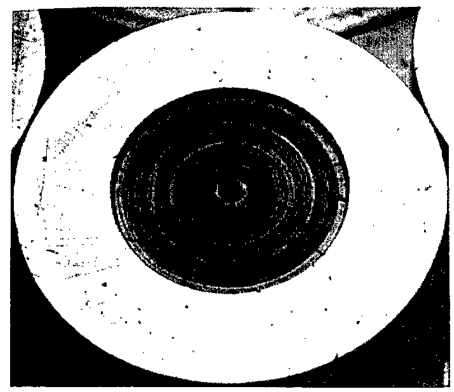


Stage III

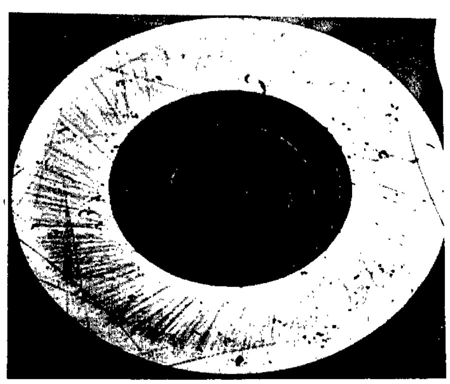
Piston 1 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



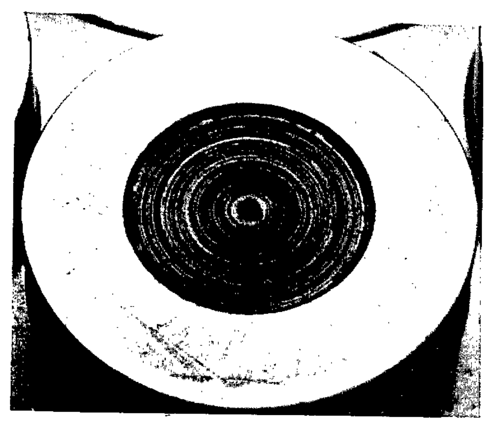
Pretest



Stage I

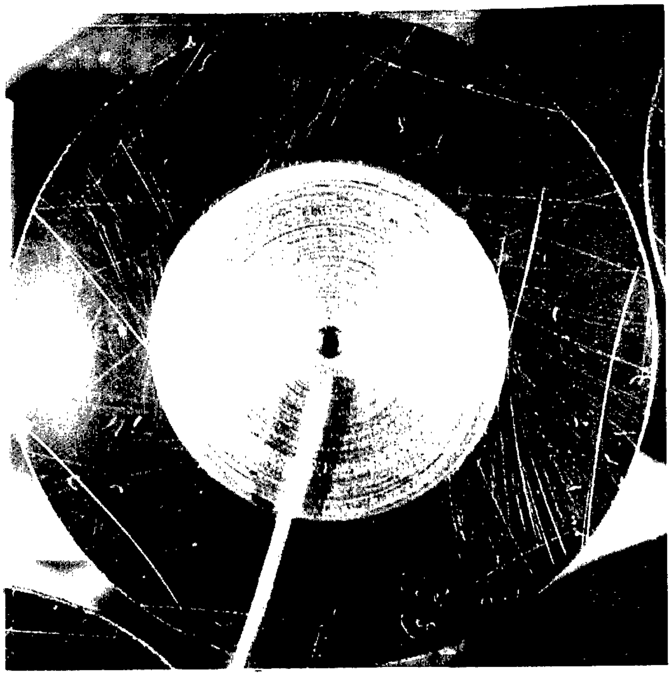


Stage II

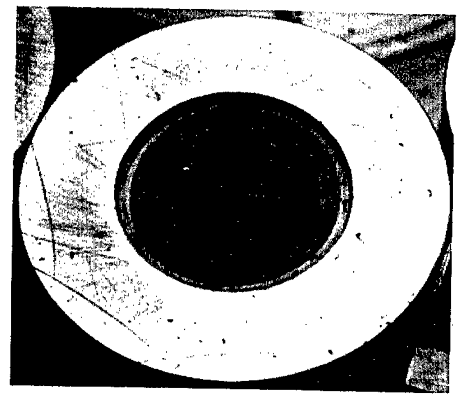


Stage III

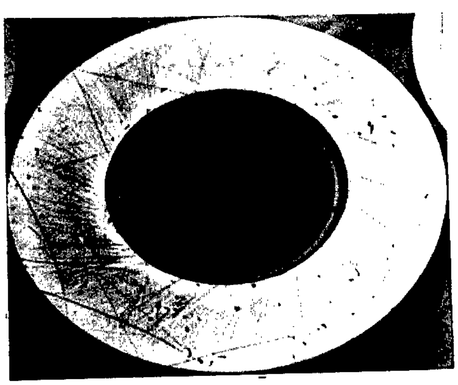
Piston 2 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



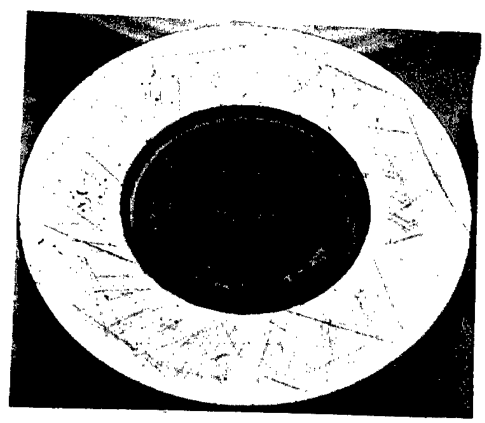
Pretest



Stage I



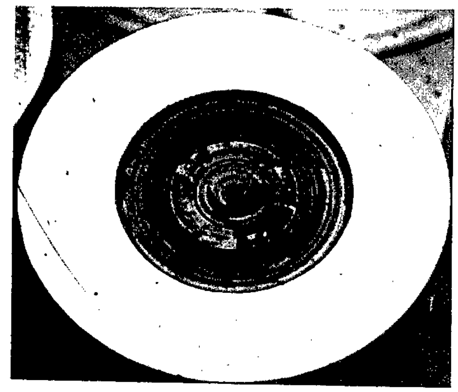
Stage II



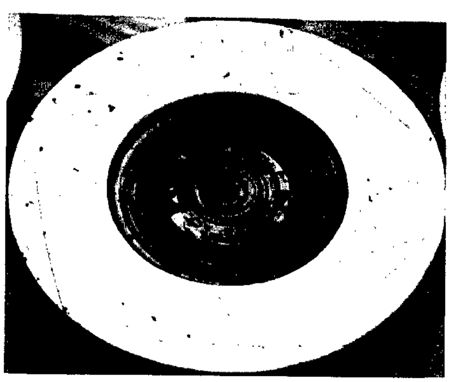
Stage III

Piston 3 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257

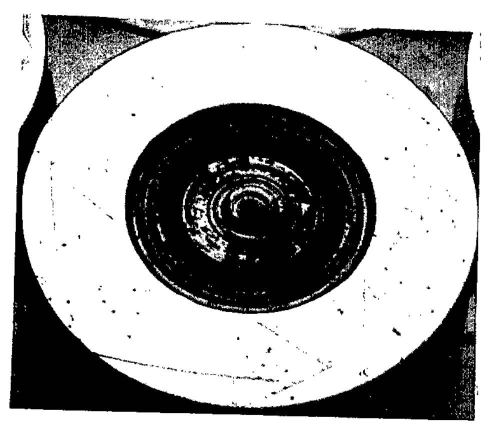
Pretest



Stage I

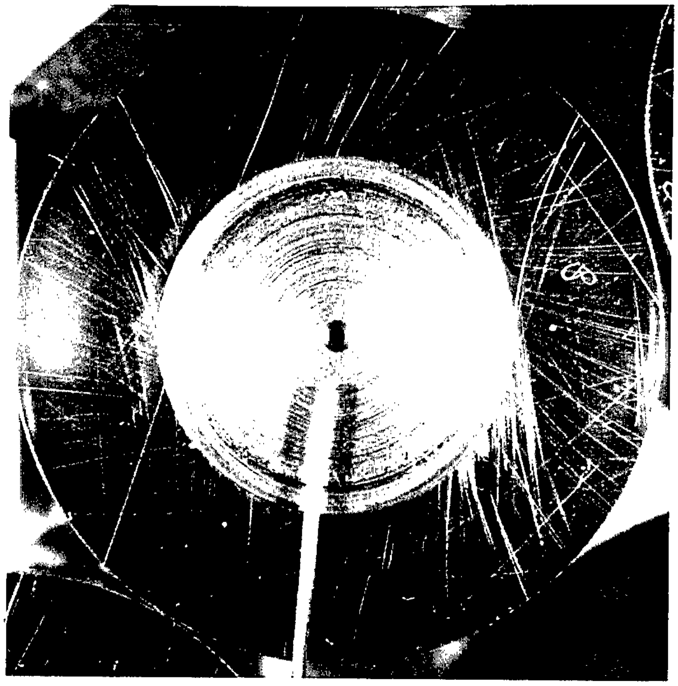


Stage II

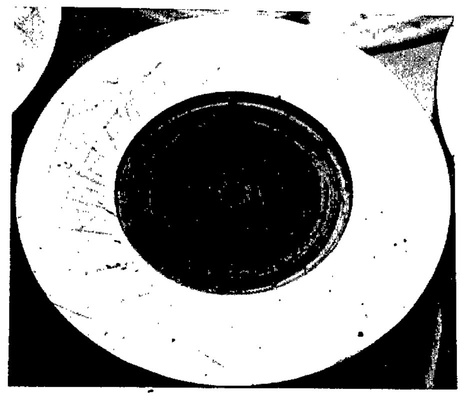


Stage III

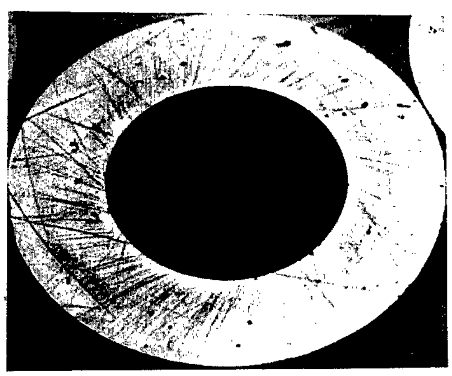
Piston 4 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



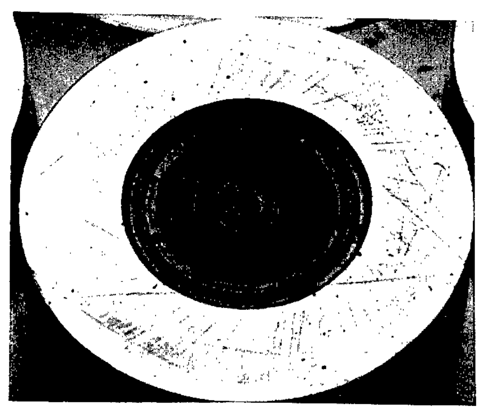
Pretest



Stage I

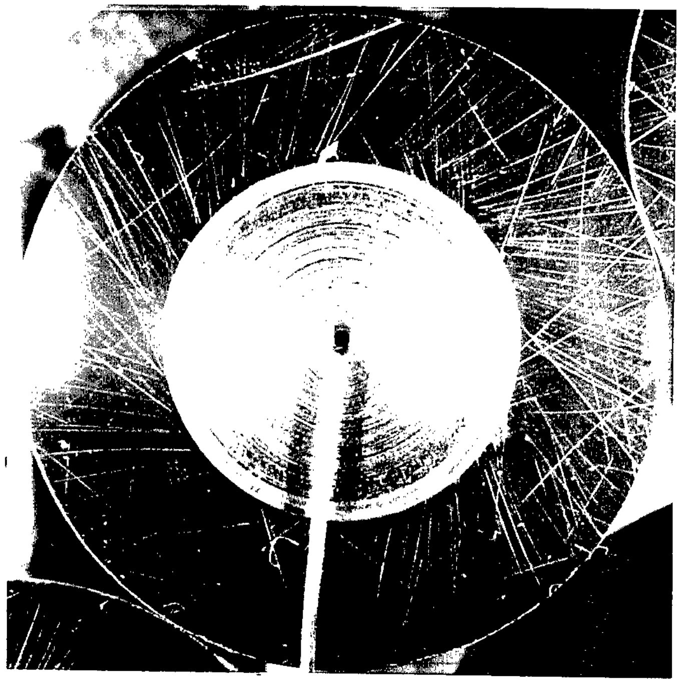


Stage II

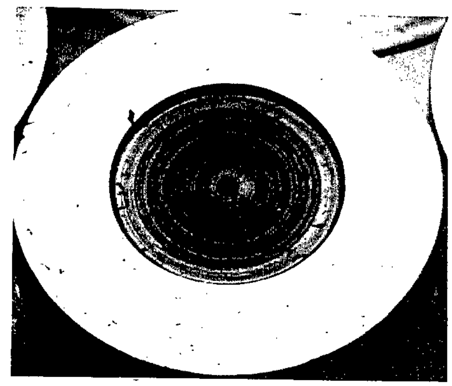


Stage III

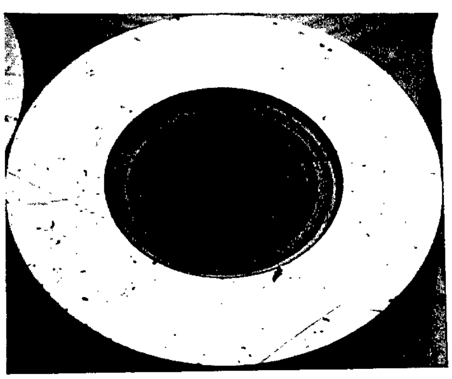
Piston 5 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



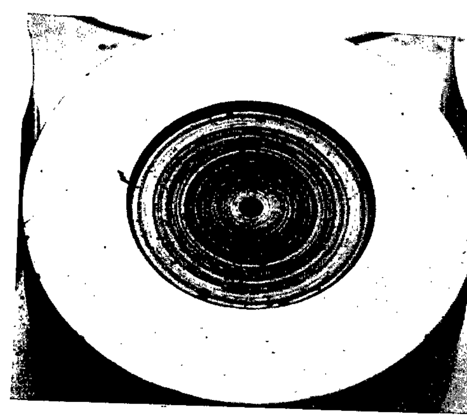
Pretest



Stage I

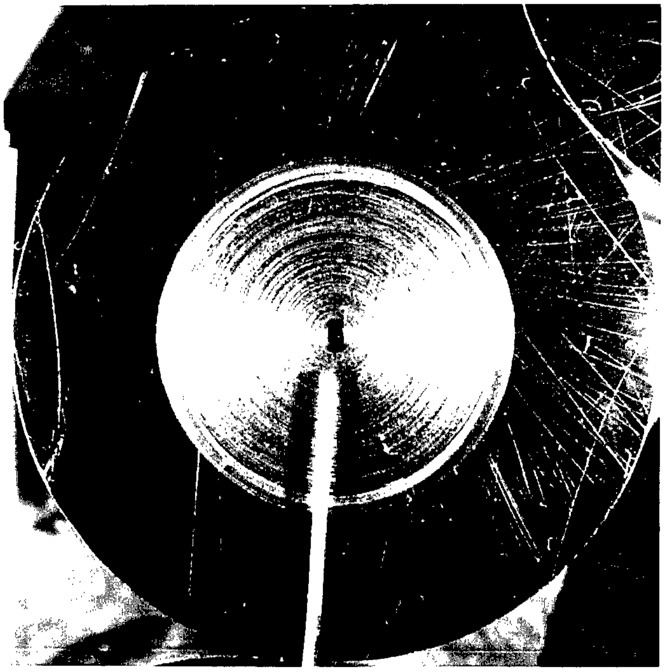


Stage II

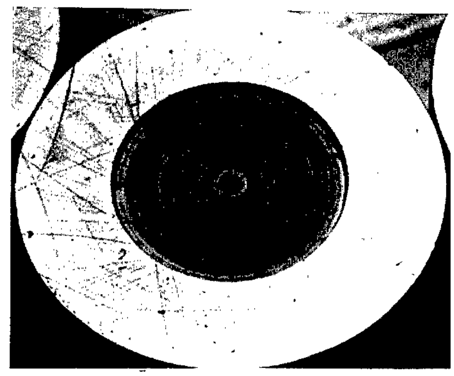


Stage III

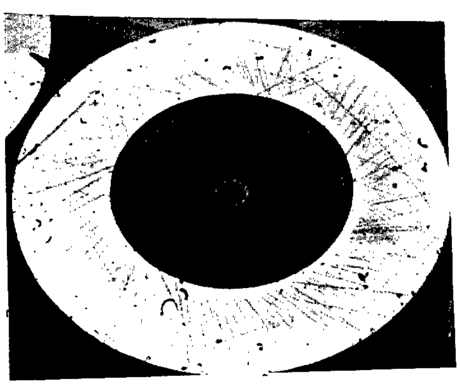
Piston 6 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



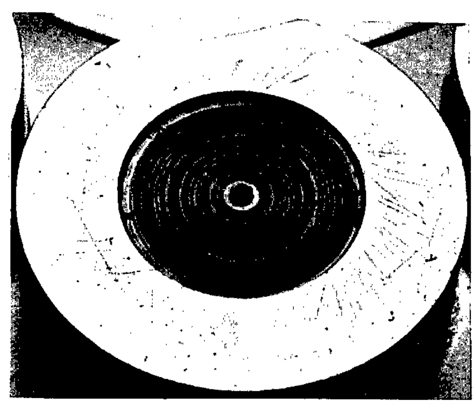
Pretest



Stage I

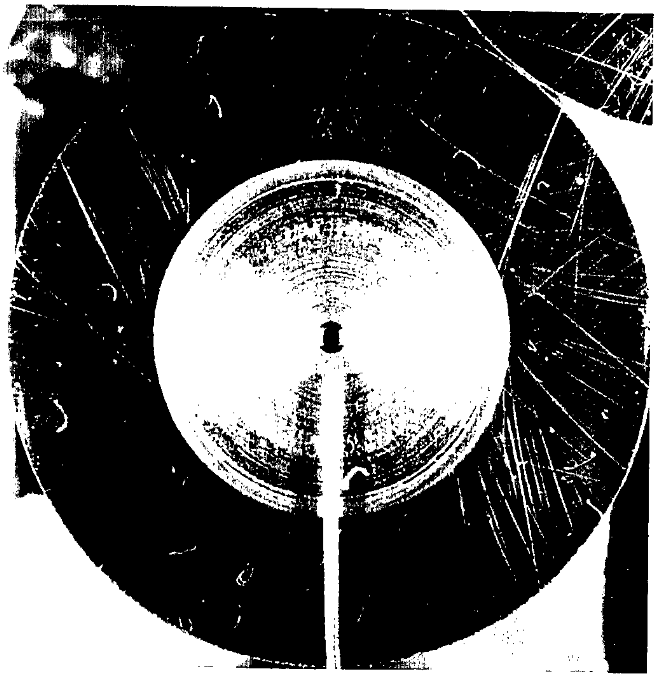


Stage II

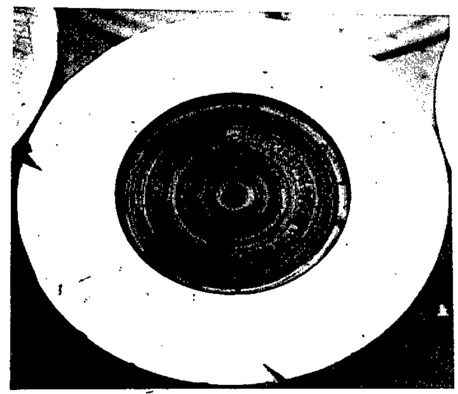


Stage III

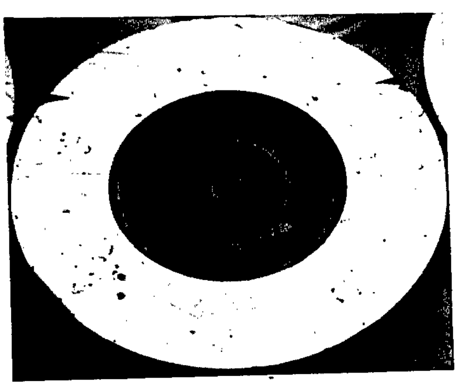
Piston 7 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



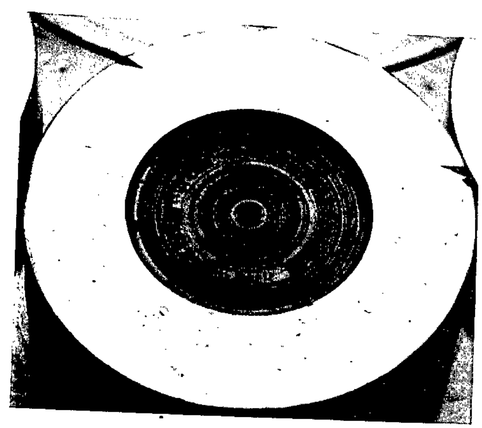
Pretest



Stage I



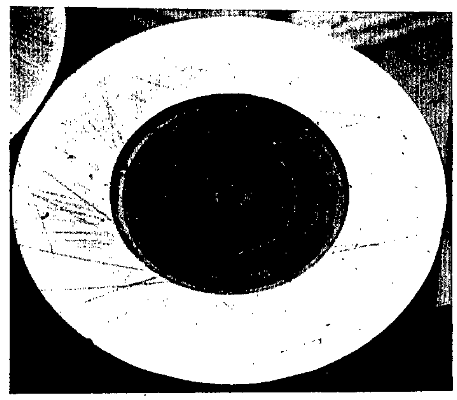
Stage II



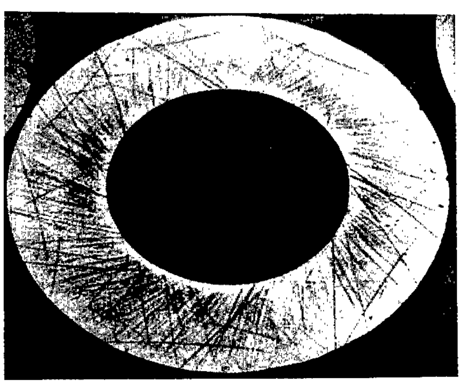
Stage III

Piston 8 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257

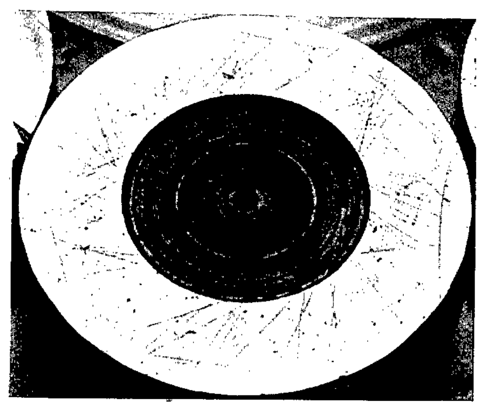
Pretest



Stage I

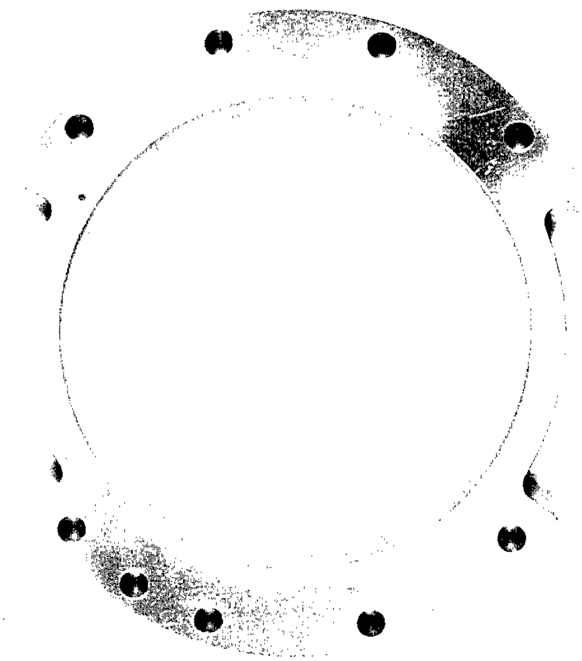


Stage II

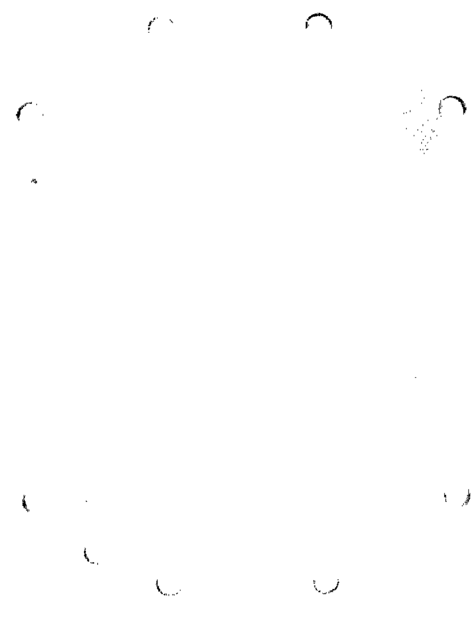


Stage III

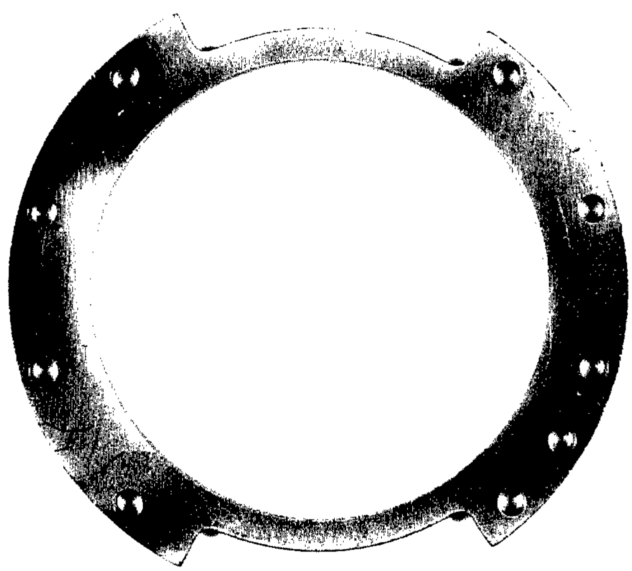
Piston 9 Shoe Face at Pretest, and After Stages I, II, and III
Pump Test 34 with MIL-H-87257



Stage I

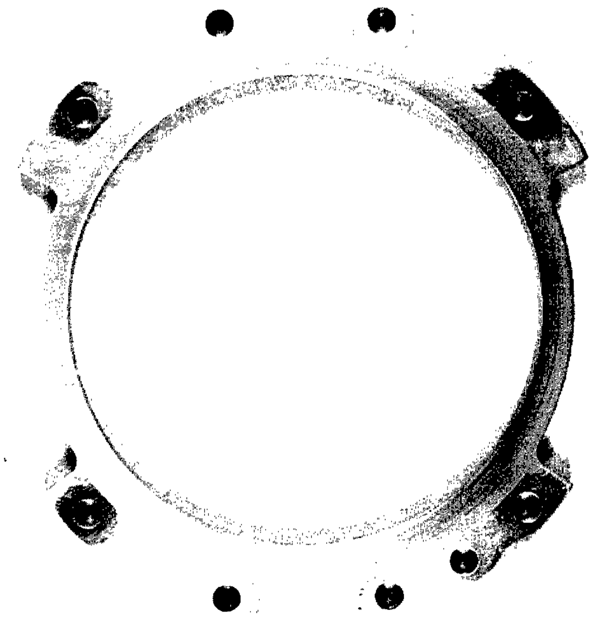


Stage II

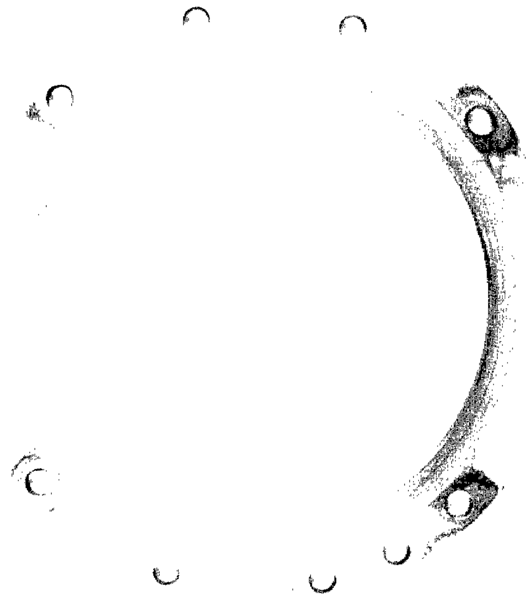


Stage III

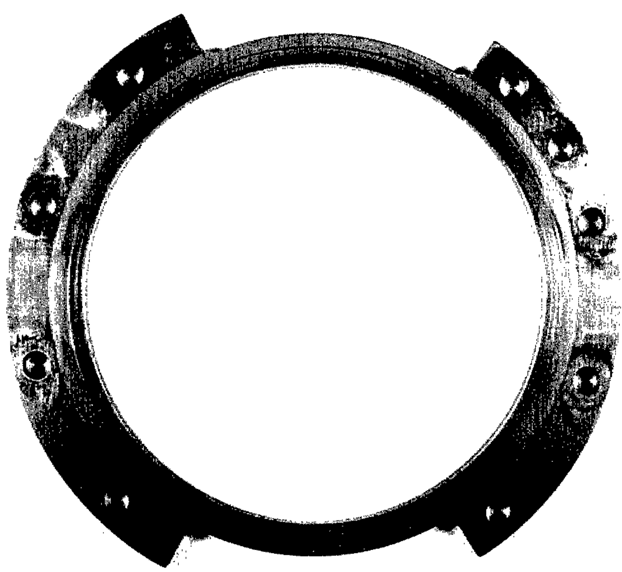
Hold Down Plate - Non Rubbing Side after Stage I, II, and III
Pump Test 34 with MIL-H-87257



Stage I

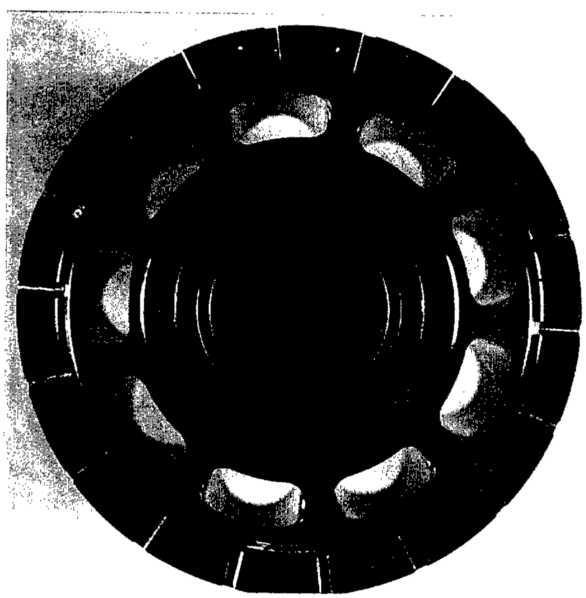


Stage II

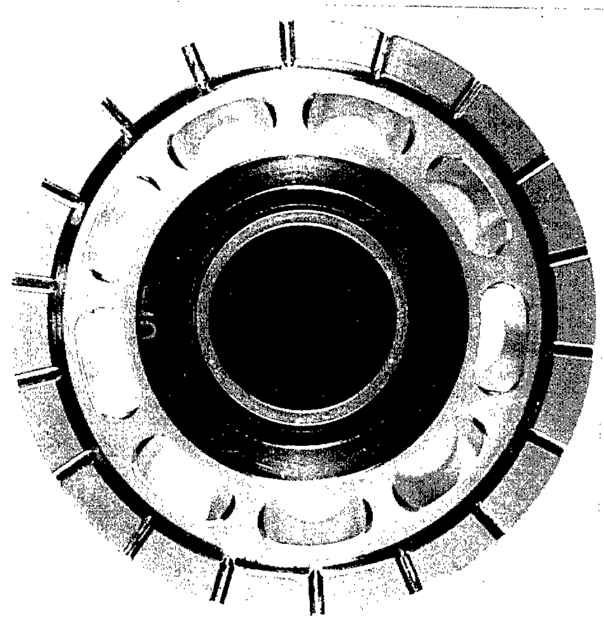


Stage III

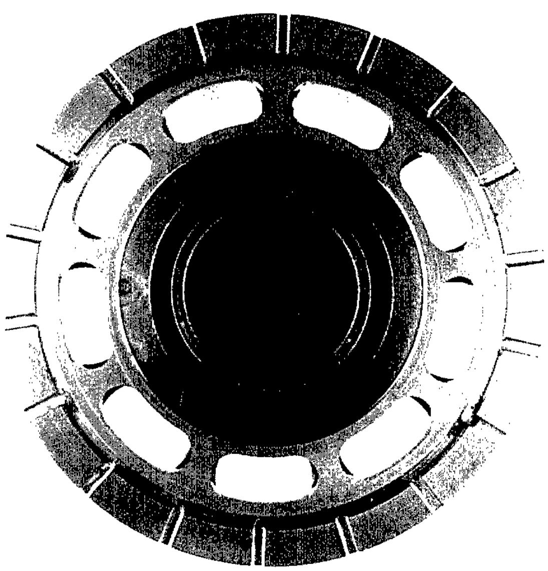
Hold Down Plate - Rubbing Side after Stage I, II, and III
Pump Test 34 with MIL-H-87257



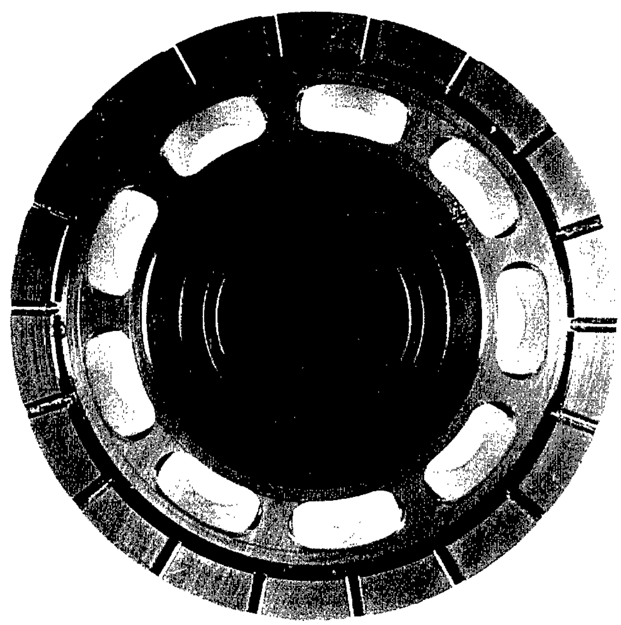
Pretest



Stage I

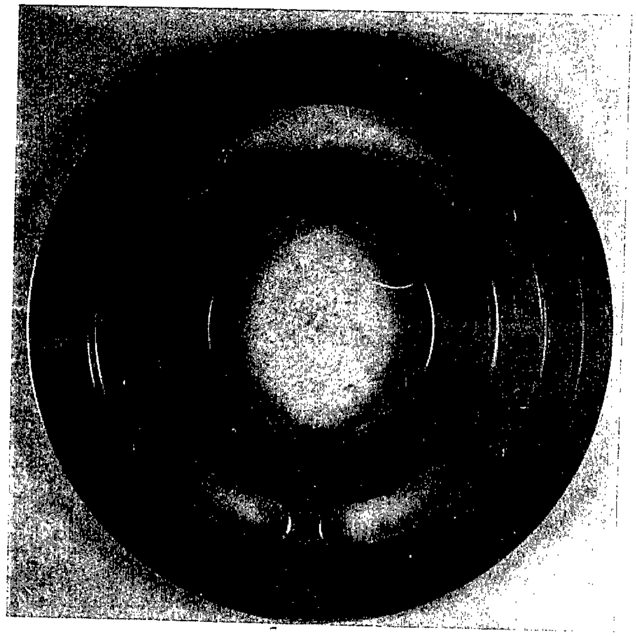


Stage II

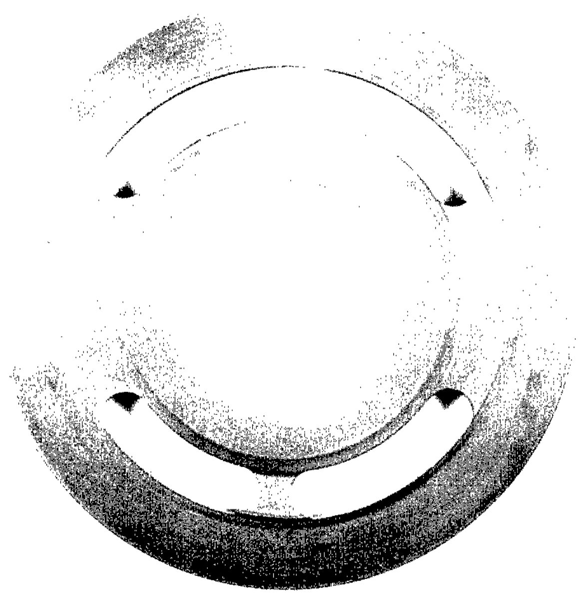


Stage III

Cylinder Block Face at Pretest and after Stage I, II, and III
Pump Test 34 with MIL-H-87257

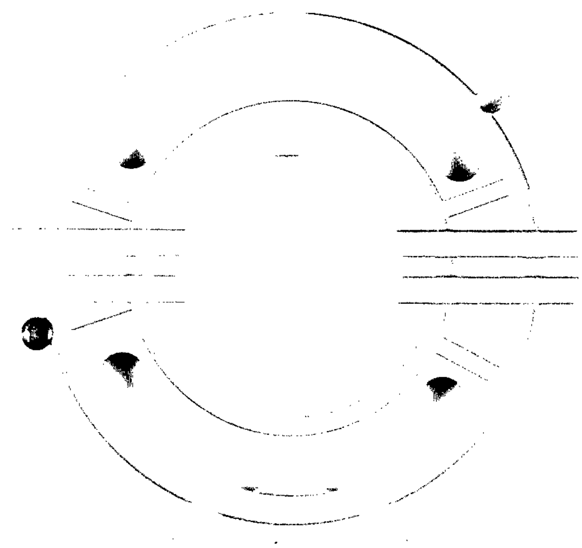


Stage I

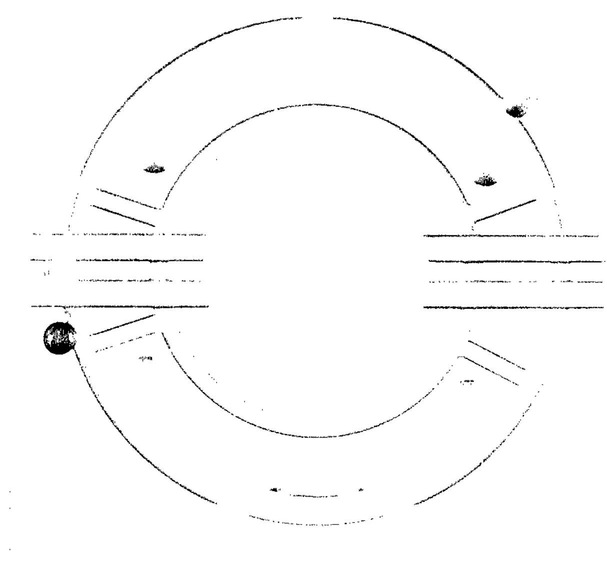


Stage II

Waffle Plate - Rubbing Side after Stage I and II
Pump Test 34 with MIL-H-87257

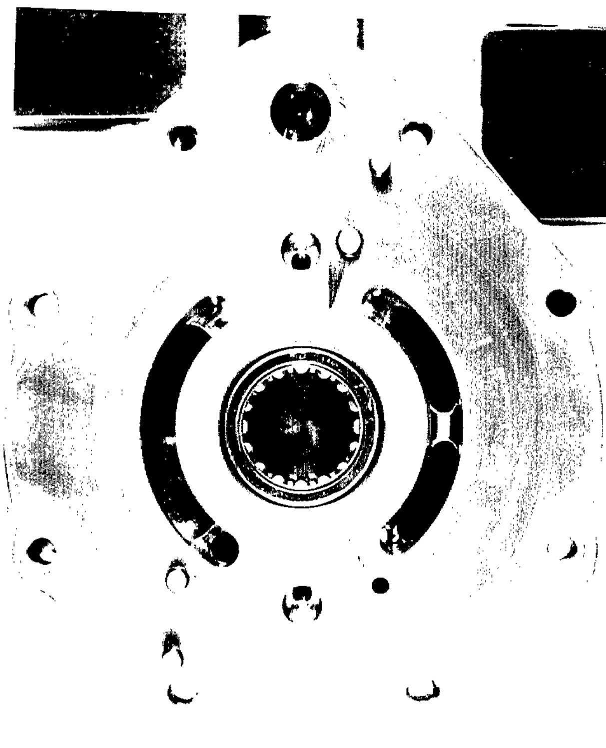


Stage I

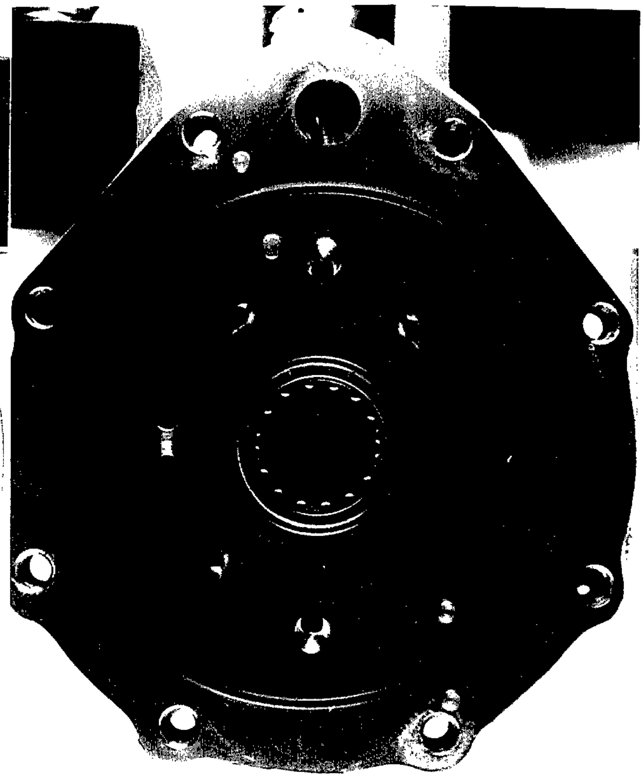


Stage II

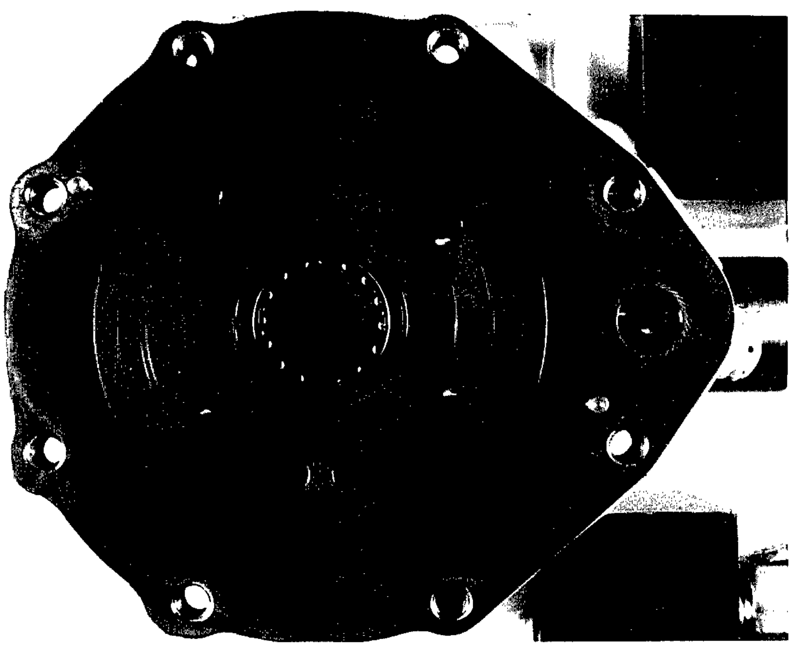
Waffle Plate - Non Rubbing Side after Stage I and II
Pump Test 34 with MIL-H-87257



Stage I



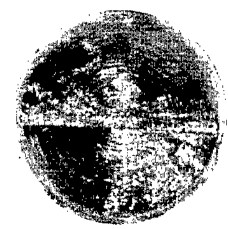
Stage II



Stage III

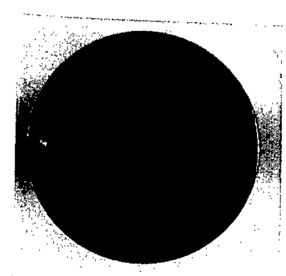
Cylinder Block Plate after Stage I, II, and III
Pump Test 34 with MIL-H-87257

Pretest



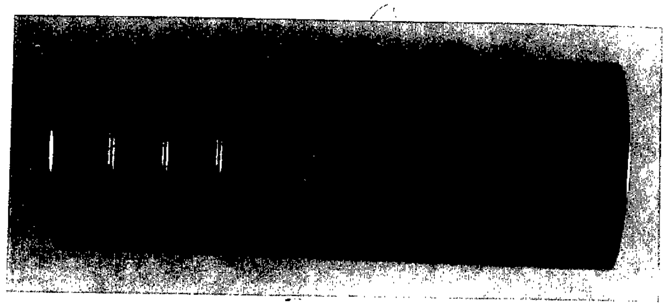
Stage I

Stage II

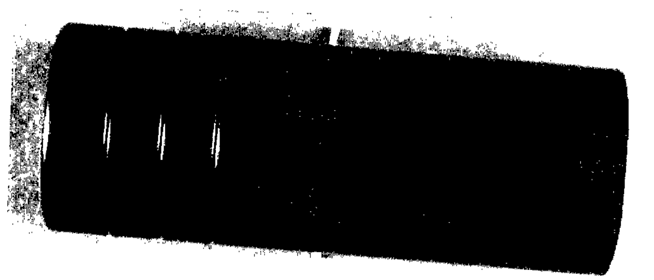


Stage III

Actuator Piston - Front View at Pretest and after Stage I, II, and III
Pump Test 34 with MIL-H-87257



Pretest

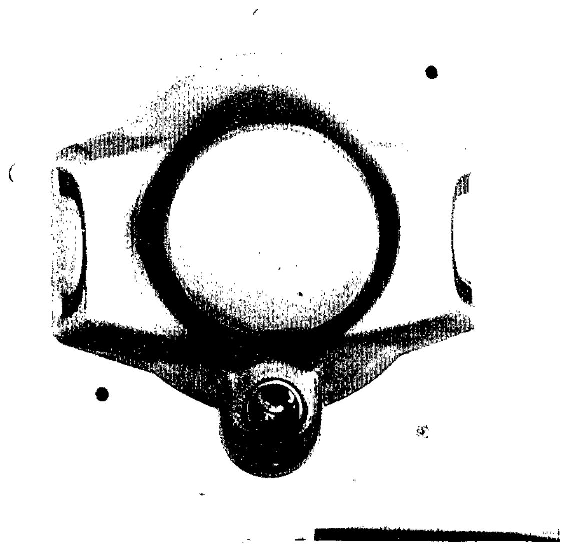


Stage I

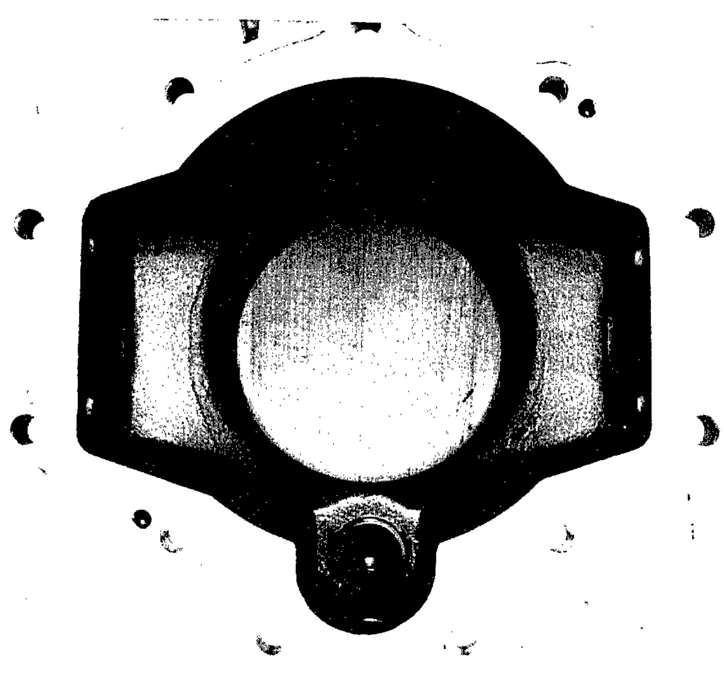
Stage II

Stage III

Actuator Piston - Side View at Pretest and after Stage I, II, and III
Pump Test 34 with MIL-H-87257

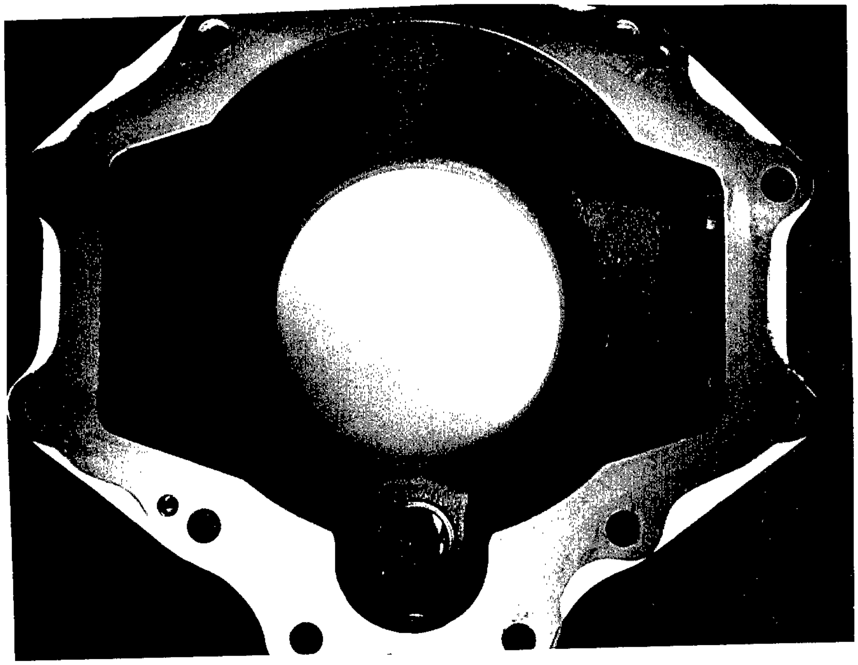


Pretest

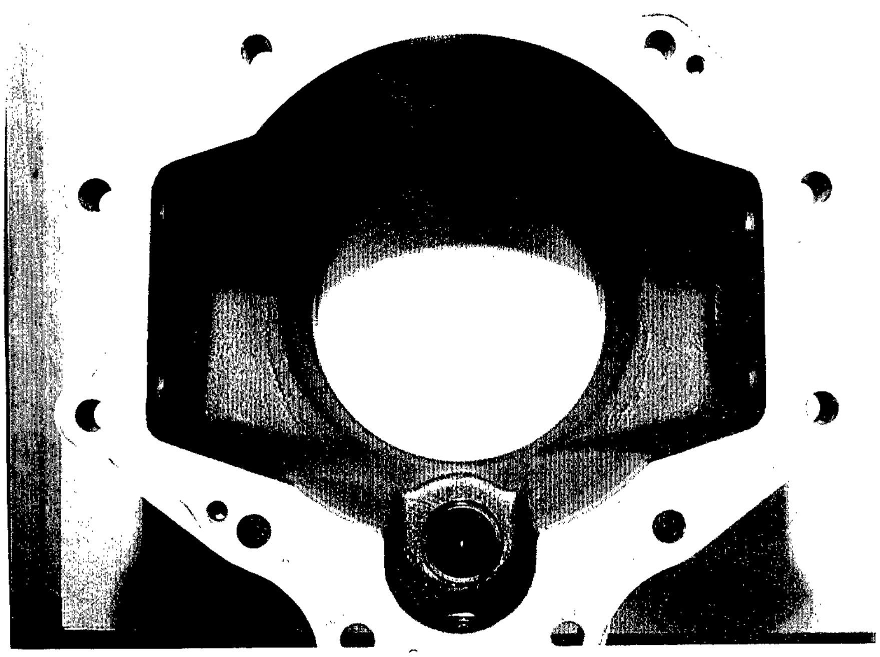


Stage I

Housing at Pretest and after Stage I
Pump Test 34 with MIL-H-87257

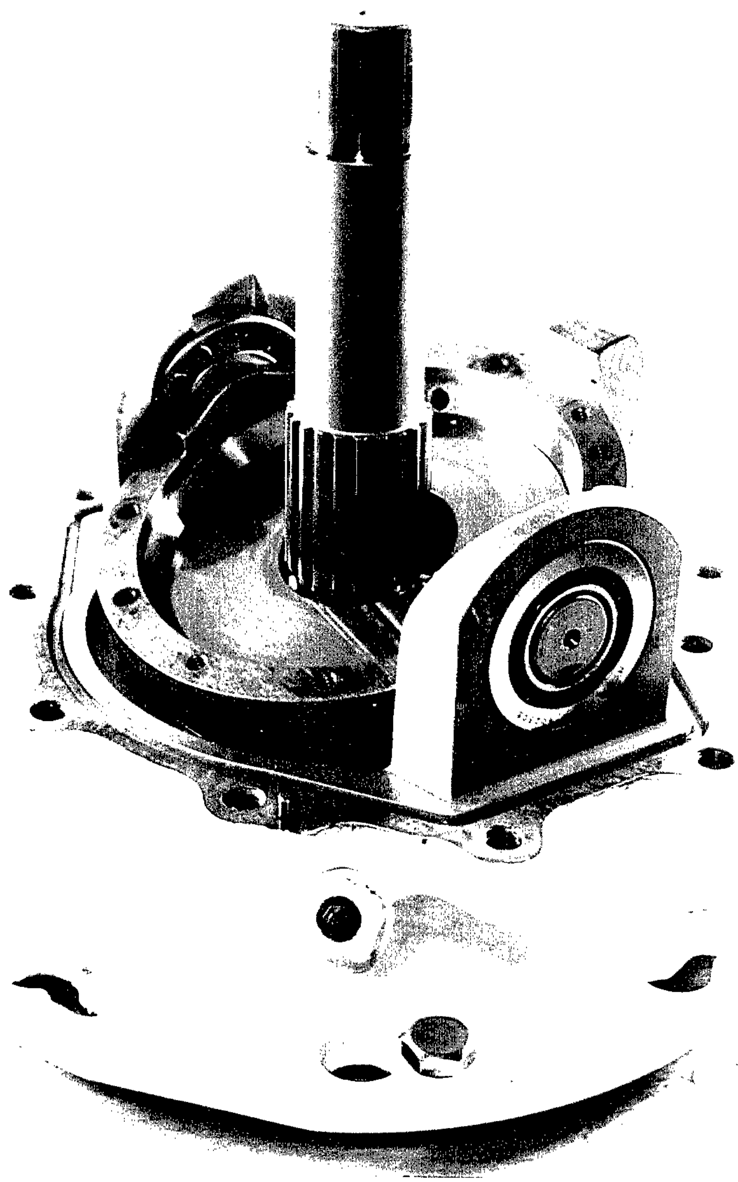


Stage II



Stage III

Housing after Stage II and III
Pump Test 34 with MIL-H-87257



Partial Assembly of Test Pump at Pretest
Pump Test 34 with MIL-H-87257

Appendix C

Raw Data for Pump Test 33

with MIL-H-5606F

PUMP TEST NO. 33

TEST PUMP : MODEL Vickers PV3-300-7B
S/N : MX 490659B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID: Mil-H-5606F
MLO 92-144

A= Throttling Valve Open
B= Throttling Valve Closed

Date	Time	Test Cell Temp. (F)	Test Hrs. (as on the counter)	Total Flow (Gallons) Main	Total Flow (Gallons) Case	Total Flow (Gallons) Disc	Resrv. Fluid Level (mm)	Total Seal Leakage (ml)	Speed (RPM) A	Speed (RPM) B	Torque (in-lbf) A	Torque (in-lbf) B	Motor Current (amps) A	Motor Current (amps) B	Pressure Drop (PSI) Main Filter 1 *** A	Pressure Drop (PSI) Main Filter 1 B	Pressure Drop (PSI) Case Filter Pall Corp. * ΔP	Pressure Drop (PSI) Case Filter Pall Corp. Deg. C	Pressure Drop (PSI) Case Filter ** A	Pressure Drop (PSI) Case Filter B	Pump Inlet Pressure (psig) A	Pump Inlet Pressure (psig) B	Pump Outlet Pressure (psig) A	Pump Outlet Pressure (psig) B
6-Jan-93	0905	65	12.0	0	0																			
6-Jan-93	0917		12.2																					
6-Jan-93	1147		14.7																					
7-Jan-93	0835	65	14.7																					
7-Jan-93	0850	65	14.9																					
7-Jan-93	1025	77	16.3	10,808	706				5,220		1752		164		26				4		92		4,136	
7-Jan-93	1205	80	18.0																					
7-Jan-93	1305	80	19.0	18,953	1,244		131.56		5,220		1759		163		26		3.6	71	5		93		4,137	
7-Jan-93	1505	72	21.0	24,956	1,646		131.56		5,220		1759		163		25		3.5	68	4		94		4,137	
7-Jan-93	1825	71	24.3	34,914	2,322		131.56		5,220		1734		163		25		3.8	68	5		95		4,140	
7-Jan-93	2140	69	27.5	44,745	2,996		131.30		5,220		1745		163		25		3.9	68	4.5		96		4,140	
7-Jan-93	2140	69	27.5																					
8-Jan-93	0115	73	31.2	55,429	3,736		131.40		5,218		1752		163		25		4.1	69	5		95		4,137	
8-Jan-93	0400	72	33.9	63,681	4,296		131.40		5,219		1752		162		25		4.2	68	5		93		4,134	
8-Jan-93	0648		36.6																					
8-Jan-93	0705		36.6																					
8-Jan-93	0825	79	38.0	75,658	5,106		131.40		5,208		1743		162		25		4.2	68	5		91		4,132	
8-Jan-93	1100	80	40.5	83,287	5,620		131.40		5,210		1750		162		25		4.3	69	5.5		92		4,131	
8-Jan-93	1220	80	42.0	87,500	5,908		131.37		5,210		1746		162		25		4.3	69	5.5		90		4,130	
8-Jan-93	1245		42.4																					
8-Jan-93	1250		42.5	89,034	6,012			250	(100-200 ml of 5606 had accumulated Inside of pump mounting flange + overboard flow through sensor,															
8-Jan-93	1445		43.2						which = approx. 250 ml.)															
28-Jan-93	1545		44.2						(Seal leakage collection in beaker started @ start of Stage II.)															
28-Jan-93	1615	82	44.7	94,746	6,406		131.50		5,215		1730		161		26		4.1	77	6		94		4,111	
28-Jan-93	1700	82	45.5	97,037	6,564		131.50	270	5,215		1718		160		25		4.0	78	7		92		4,106	
28-Jan-93	1937	80	48.1	104,924	7,128		131.50	320	5,218		1708				24		3.9	79	6		91		4,102	
28-Jan-93	2100		49.5																					
29-Jan-93	0040	83	53.1	119,760	8,224		131.30	330	5,217		1767		163		26		4.0	75	7		94		4,108	
29-Jan-93	0338	82	56.1	128,843	8,892		131.30	340	5,217		1733		161		25		3.9	75	7		93		4,104	
29-Jan-93	0522	86	57.9	134,120	9,292		131.30	350	5,218		1710		159		24		3.8	77	8		89		4,106	
29-Jan-93	0550		58.3																					
29-Jan-93	0700		59.5	138,920																				
29-Jan-93	0730	84	60.0	140,419	9,768		131.20	360	5,215		1709		159		25		3.8	78	7		92		4,105	
29-Jan-93	0930	87	62.0	146419	10,216		131.20	370	5,215		1721		160		25		3.7	78	8		93		4,107	

* Static Reading (Offset) : During Stage I & Stage II = 3.0 psi.; Before Stage III = 2.6 psi.; After Stage III = 0.1 psi.

** Static Reading (Offset) During the Whole Test = -7.0 psi.

*** Static Reading (Offset) During the Whole Test = -4.0 psi.

PUMP TEST NO. 33

TEST PUMP : MODEL Vickers PV3-300-7B
S/N: MX 490659B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID :
Mil- H-5606F
MLO 92-144

A= Throttling Valve Open
B= Throttling Valve Closed

Test Hrs.	Coolant Flow (GPM)		Flow Rate (GPM)						Fluid Temperature (F)								Coolant Temperature (F)				REMARKS
			Main		Case		Disk		Pump Inlet		Pump Outlet		Case Drain		TV Outlet		Heat Exchanger Inlet		Heat Exchanger Outlet		
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
12.0						12.0 hours on pump for test stand refinement.															Stage I - Test Start.
12.2																					Sample Taken (Stage I - 0.2 hrs.)
14.7																					Manual Shutdown.
14.7																					Test Restart.
14.9																					Auto Shutdown @ 14.9 hrs., cause unknown. Test Restart.
16.3			50.27		3.30				180		189		222		209		83		104		
18.0																					Sample Taken (Stage I - 6 hrs.)
19.0			50.30		3.40				180		188		222		209		83		104		
21.0			50.30		3.40				178		187		220		208		84		104		
24.3			49.60		3.40				179		188		220		208		87		107		
27.5			49.90		3.40				178		187		219		207		86		107		
27.5																					Sample Taken (Stage I - 15.5 hrs.)
31.2			50.20		3.50				179		188		220		209		89		109		
33.9			50.20		3.50				179		189		220		209		89		110		
36.6																					Manual Shutdown @ 36.6 - Computer problem.
36.6																					Test Restart
38.0			49.90		3.30				178		187		219		207		87		108		
40.5			50.10		3.40				178		187		219		207		89		109		
42.0			50.10		3.40				177		187		219		207		87		108		
42.4																					Sample Taken (Stage I - 30 hrs.)
42.5																					Test stopped for inspection after stage I
43.2																					Stage II - Test Start
44.2																					Sample Taken (Stage II - 1 hr.)
44.7			50.20		3.50				205		214		244		234		122		144		
45.5			49.70		3.50				211		220		249		239		130		150		
48.1			49.60		3.60				214		223		252		242		136		155		
49.5																					Sample Taken (Stage II - 6.3 hrs.)
53.1			51.20		3.80				207		216		246		236		127		147		
56.1			50.10		3.80				211		220		249		239		134		153		
57.9			49.42		3.80				211		220		249		240		134		154		
58.3																					Sample Taken (Stage II - 15.1 hrs.)
59.5																					Broken wire repaired - Main flow update
60.0			49.45		3.80				208		219		248		238		134		153		
62.0			49.75		3.80				210		220		248		239		134		154		

PUMP TEST NO. 33

TEST PUMP : MODEL Vickers PV3-300-7B
S/N : MX 490659B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID: Mil-H-5606F
MLO 92-144

A= Throttling Valve Open
B= Throttling Valve Closed

Date	Time	Test Cell Temp. (F)	Test Hrs. (as on the counter)	Total Flow (Gallons) Main	Total Flow (Gallons) Case	Total Flow (Gallons) Disc	Resrv. Fluid Level (mm)	Total Seal Leakage (ml)	Speed (RPM) A	Speed (RPM) B	Torque (in-lbf) A	Torque (in-lbf) B	Motor Current (amps) A	Motor Current (amps) B	Pressure Drop (PSI) Main Filter 1 *** A	Pressure Drop (PSI) Main Filter 1 B	Pressure Drop (PSI) Case Filter Pall Corp. * ΔP	Pressure Drop (PSI) Case Filter Pall Corp. Deg. C	Pressure Drop (PSI) Case Filter ** A	Pressure Drop (PSI) Case Filter B	Pump Inlet Pressure (psig) A	Pump Inlet Pressure (psig) B	Pump Outlet Pressure (psig) A	Pump Outlet Pressure (psig) B
29-Jan-93	1302	86	65.5	157,108	11,028		131.07	415	5,215		1746		161		26		3.6	77	7		90		4,102	
29-Jan-93	1812	81	70.7	172,598	12,196		130.90	480	5,215		1727		161		25		3.3	73	7		96		4,109	
29-Jan-93	2016	81	72.8	178,797	12,674		130.90	500	5,212		1726		161		24		3.2	75	7		90		4,104	
29-Jan-93	2040		73.2																					
29-Jan-93	2042		73.2	179,997	12,768																			
17-Feb-93	0905		76.4																					
17-Feb-93	0917		76.6																					
17-Feb-93	0930		76.7																					
17-Feb-93	1006	83	78.3	193,369	13,854			500	5,230		1734		163		23		2.8	85	7		94		4,078	
17-Feb-93	1145	85	78.9	195,333	14,028			500	5,230		1731		163		23		2.7	86	8		91		4,072	
17-Feb-93	1430	87	81.6	203,566	14,762			500	5,240		1721		161		22		2.4	88	8		93		4,071	
17-Feb-93	1536		82.7																					
17-Feb-93	1710	88	84.3	211,643	15,490			500	5,240		1729		161		23		2.0	89	8		93		4,070	
17-Feb-93	2015	91	89.4	227,216	16,906				5,245		1743		162		23		1.4	92	8		93		4,070	
18-Feb-93	0015		91.4																					
18-Feb-93	0500	93	96.2	247,478	18,760			500	5,245		1745		162		23		0.7	95	8		92		4,069	
18-Feb-93	0805	90	99.2	256,652	19,620				5,240		1728		160		23		0.3	98	8		91		4,065	
18-Feb-93	1422	91	105.6	275,677	21,424				5,240		1725		160		22		-0.1	98	8		94		4,064	
18-Feb-93	1445		106.0	276,964	21,544																			
19-Feb-93	0900		106.0																					

* Static Reading (Offset) : During Stage I & Stage II = 3.0 psi.; Before Stage III = 2.6 psi.; After Stage III = 0.1 psi.

** Static Reading (Offset) During the Whole Test = -7.0 psi.

*** Static Reading (Offset) During the Whole Test = -4.0 psi.

PUMP TEST NO. 33

TEST PUMP : MODEL Vickers PV3-300-7B
S/N: MX 490659B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID :
Mil- H-5606F
MLO 92-144

A= Throttling Valve Open
B= Throttling Valve Closed

Test Hrs.	Coolant Flow (GPM)		Flow Rate (GPM) Main		Flow Rate (GPM) Case		Flow Rate (GPM) Disk		Fluid Temperature (F) Pump Inlet		Fluid Temperature (F) Pump Outlet		Fluid Temperature (F) Case Drain		Fluid Temperature (F) TV Outlet		Coolant Temperature (F) Heat Exchanger Inlet		Coolant Temperature (F) Heat Exchanger Outlet		REMARKS
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
65.5			50.65		3.80				208		217		246		236		131		151		
70.7			49.90		3.90				209		218		246		237		134		154		
72.8			49.90		3.90				210		219		248		239		137		156		
73.2																					Sample Taken (Stage II - 30 hrs.)
73.2																					Test Stopped for inspection.
76.4																					Stage III - Test Started
76.6																					Sample Taken (Stage III - 0.2 hrs.)
76.7																					Stage III - Test Restarted after unexplained shutdown.
78.3			50.25		4.40				247		257		281		275		183		203		
78.9			50.07		4.50				249		259		284	270	277		187		206		Pump Bybass-B := Case temp. @ filter inlet
81.6			50.12		4.60				250		259		283	270	277		187		208		
82.7																					Sample Taken (Stage III - 6 hrs.)
84.3			50.14		4.60				249		258		283	270	276		187		208		
89.4			50.64		4.70				249		257		282	268	275		187		209		
91.4																					Sample Taken (Stage III - 15 hrs.)
96.2			50.60		4.70				249		258		282	268	276		188		211		
99.2			50.00		4.80				249		259		283	270	276		191		213		
105.6			50.00		4.80				251		261		285		278		195		215		
106.0																					Auto Shutdown.
106.0	Three samples taken : 1)Main return line, 2)Heat exch. inlet line, 3)Pump case drain after removing pump.																				Test #33 Completed.

Appendix D

Raw Data for Pump Test 34

with MIL-H-87257

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N : MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID:
Mil-H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Date	Time	Test Cell Temp. (F)	Test Hrs. (as on the counter)	Total Flow (Gallons) Main	Total Flow (Gallons) Case	Resrv. Fluid Level (mm)	Total Seal Leakage (ml)	Speed (RPM) A	Speed (RPM) B	Torque (in-lbf) A	Torque (in-lbf) B	Motor Current (amps) A	Motor Current (amps) B	Pressure Drop (PSI) Main Filter 1 ΔΔ A	Pressure Drop (PSI) Main Filter 1 B	Pressure Drop (PSI) Case Filter Pressure (psi) inlet	Pressure Drop (PSI) Case Filter Pressure (psi) outlet	Pressure Drop (PSI) Case Filter Δ A	Pressure Drop (PSI) Case Filter B	Pump Case Outlet Pressure (psig)	Pump Inlet Pressure (psig) A	Pump Inlet Pressure (psig) B	Pump Outlet Pressure (psig) A	Pump Outlet Pressure (psig) B
25-Mar-93	0937		0.0																					
25-Mar-93	0943		0.1																					
25-Mar-93	0955		0.3																					
31-Mar-93	0945		0.3																					
31-Mar-93	1030	75	1.0	2387	156			5230		1731		168		20		92	96	0			92		4194	
31-Mar-93	1305		3.6																					
31-Mar-93	1338		3.6																					
31-Mar-93	1400	76	3.9	10885	758	131.94		5210		1734		164		21		93	97	0			93		4193	
31-Mar-93	1605	78	6.1																					
31-Mar-93	1802	78	9.0	26111	1798	131.75		5206		1730		160		20		95	99	1			95		4192	
31-Mar-93	2030	78	10.4	30456	2094	131.75		5208		1745		161		22		96		1			95		4190	
31-Mar-93	2100		11.0																					
31-Mar-93	2110		11.2																					
1-Apr-93	2300		12.9	37175	2560	131.75		5220		1726		160		20		92	96	0			92		4184	
1-Apr-93	0125		15.3																					
1-Apr-93	0200	77	15.9	46175	3182			5220		1739		161		21		92	96	1			91		4182	
1-Apr-93	0500	76	18.9	55063	3798	131.56	20	5220		1726		160		21		94	97	1			93		4185	
1-Apr-93	0710	76	21.1	61416	4236			5220		1721		160		21		94	97	1			93		4186	
1-Apr-93	0900	76	22.9	66927	4618	131.56	20	5220		1719		160		21		93	97	1			92		4184	
1-Apr-93	0912		23.1																					
2-Apr-93	0834	68	23.1																					
2-Apr-93	0844		23.3																					
2-Apr-93	0855		23.3																					
2-Apr-93	1035	76	25.0	72705	5016	132.75	25	5230		1721		161		21		92	96	1			92		4183	
2-Apr-93	1136	77	26.0	75741	5230			5230		1726		160		21		92	96	1			92		4184	
2-Apr-93	1248	77	27.2	79354	5482			5230		1721		160		21		93	96	1			91		4184	
2-Apr-93	1414	78	28.6	83586	5774			5230		1722		160		21		92	96	1			92		4183	
2-Apr-93	1547	77	30.2	88261	6098	132.25	30	5230		1715		160		21		91	95	1			90		4178	
2-Apr-93	1555		30.3																					
2-Apr-93	1555		30.3																					
14-Apr-93	0848		30.3																					
14-Apr-93	0912		30.7																					
14-Apr-93	0920		30.7																					
14-Apr-93	0926		30.8																					

Δ Static Reading (Offset) During the Whole Test = -9.0 psi.
ΔΔ Static Reading (Offset) During the Whole Test = -6.0 psi.

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N: MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID :
Mil- H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Test Hrs.	Coolant Flow (GPM)		Flow Rate (GPM) Main		Flow Rate (GPM) Case		Flow Rate (GPM) Disk		Fluid Temperature (F) Pump Inlet		Fluid Temperature (F) Pump Outlet		Fluid Temperature (F) Case Drain		Fluid Temperature (F) TV Outlet		Coolant Temperature (F) Heat Exchanger Inlet		Coolant Temperature (F) Heat Exchanger Outlet		REMARKS
	A	B	A	B	A	B	A	B	A	B	A	B	A *	B **	A	B	A	B	A	B	
0.0																					Stage I - Test Start.
0.1																					Sample Taken (Stage I-0.1 hrs.).
0.3																					Manual Shutdown (Cooling water leak).
0.3																					Test Restart.
1.0			49.8		3.6				181		190		219		209		83		124		
3.6																					Auto Shutdown (Reason Unknown).
3.6																					Test Restart.
3.9			49.8		3.5				181		191		216		210		83		126		
6.1																					Sample Taken (Stage I-6.1 hrs.).
9.0			50.0		3.4				181		190		216		209		83		124		
10.4			50.3		3.4				181		190		217		209		84		123		
11.0																					Auto Shutdown (Operator error while changing warning settings).
11.2																					Test Restart
12.9			49.9		3.5				181		190		212		209		84		124		
15.3																					Sample Taken (Stage I-15.3 hrs.).
15.9			50.2		3.5				181		190		213		210		84		124		
18.9			49.8		3.5				181		190		212		209		84		124		
21.1			49.7		3.5				181		190		212		209		84		123		
22.9			49.7		3.5				181		190		212		209		84		124		
23.1																					Manual Shutdown .
23.1																					Test Restart.
23.3																					Auto Shutdown (Reason Unknown).
23.3									Bypass T/C bed @ 23.3 hrs. Reading from Omega. (Case filter inlet Temp.)												Test Restart.
25.0			49.7		3.5				181		190			218	209		83		124		
26.0			49.8		3.5				181		190			216	209		83		123		
27.2			49.7		3.5				181		190			218	209		82		124		
28.6			49.8		3.5				180		190			218	209		82		124		
30.2			49.6		3.4				179		189			216	208		82		122		
30.3																					Sample Taken (Stage I-30.3 hrs.).
30.3																					Manual Shutdown - Stage I Completed - Pump Inspected.
30.3																					Stage II - Test Start.
30.7																					Auto Shutdown (Reason Unknown).
30.7																					Test Restart.
30.8																					Sample Taken (Stage II-30.8 hrs.).

* At pump case outlet.
** At pump case filter inlet (after case flow heat exchanger; before inlet to case filter).

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N : MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID:
Mil-H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Date	Time	Test Cell Temp. (F)	Test Hrs. (as on the counter)	Total Flow (Gallons) Main	Total Flow (Gallons) Case	Resrv. Fluid Level (mm)	Total Seal Leakage (ml)	Speed (RPM) A	Speed (RPM) B	Torque (in-lbf) A	Torque (in-lbf) B	Motor Current (amps) A	Motor Current (amps) B	Pressure Drop (PSI) Main Filter 1 ΔΔ A	Pressure Drop (PSI) Main Filter 1 B	Case Filter Pressure (psi) inlet	Case Filter Pressure (psi) outlet	Case Filter Δ A	Case Filter B	Pump Case Outlet Pressure (psig)	Pump Inlet Pressure (psig) A	Pump Inlet Pressure (psig) B	Pump Outlet Pressure (psig) A	Pump Outlet Pressure (psig) B
14-Apr-93	1045	78	32.1	93607	6526	131.75		5218		1730		162		16		93	95	0		136	92		4161	
14-Apr-93	1404	80	35.4	103369	7310			5218		1712		159		16		92	94	0		138	92		4161	
14-Apr-93	1455		36.3																					
14-Apr-93	1730	83	38.9	113726	8134	131.68		5217		1725		160				96	98			144	96		4161	
14-Apr-93	2055	82	44.3	129786	9404	131.56		5215		1746		161				94	96			144	94		4160	
15-Apr-93	0000		45.4																					
15-Apr-93	0342	82	49.1	144339	10546	131.44	50	5215		1727		160		17		96	96			144	95		4160	
15-Apr-93	0555	82	51.3	150997	11066	131.44	50	5215		1726		160		17		96	96	0		144	96		4161	
15-Apr-93	0855	80	54.3	159951	11776	131.44	50	5215		1716		160		17		94	94	0		141	94		4160	
15-Apr-93	1245	81	58.2	171531	12686	131.44	50	5215		1752		162		17		95	96	0		143	95		4157	
15-Apr-93	1448	81	60.2	177564	13162	131.41	50	5217		1726		160		17		94	96			140	94		4159	
15-Apr-93	1455		60.3																					
15-Apr-93	1458		60.3																					
26-Apr-93	1355		60.4																					
26-Apr-93	1413		60.7																					
26-Apr-93	1420		60.7																					
26-Apr-93	1435		60.9																					
26-Apr-93	1530	85	61.8	181904	13522			5230		1721		162		14		92	93	1			93		4127	
26-Apr-93	1720		63.6		14494																			
26-Apr-93	1825	86	64.7	190690		132.38	60	5230		1708		159		14		92	93	0			91		4119	
26-Apr-93	1930		65.9		15736																			
26-Apr-93	2025		66.7																					
26-Apr-93	2125		67.7	199650	16708	132.19	70	5230		1704		159		14		92	93	1			92		4119	
26-Apr-93	2310	81	69.5	204935	17178	132.17	70	5230		1710		160		15		98	98	1			97		4124	
27-Apr-93	0018		70.8																					
27-Apr-93	0040		70.8																					
27-Apr-93	0130		71.5			Manual Shutdown (Fluid overflow through relief valve in high pressure line).																		
28-Apr-93	0638		71.6																					
28-Apr-93	0702		72.0																					
28-Apr-93	0704		72.0																					
28-Apr-93	0823		73.3																					
28-Apr-93	1013		73.3																					
28-Apr-93				Test stopped & restarted several times. Inlet & outlet T/C flucuating (opening & closing). Thought excessive vibrations may be the cause. (See next page same line).																				
30-Apr-93	0955		74.8																					
30-Apr-93	1006		75.0																					
30-Apr-93	1012		75.0																					
30-Apr-93	1055	87	75.7	221105	18574			5230		1712		163		14		92	94	0			92		4126	

Δ Static Reading (Offset) During the Whole Test = -9.0 psi.
ΔΔ Static Reading (Offset) During the Whole Test = -6.0 psi.

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N: MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID :
Mil- H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Test Hrs.	Coolant Flow (GPM)		Flow Rate (GPM) Main		Flow Rate (GPM) Case		Flow Rate (GPM) Disk		Fluid Temperature (F) Pump Inlet		Fluid Temperature (F) Pump Outlet		Fluid Temperature (F) Case Drain		Fluid Temperature (F) TV Outlet		Coolant Temperature (F) Heat Exchanger Inlet		Coolant Temperature (F) Heat Exchanger Outlet		REMARKS
	A	B	A	B	A	B	A	B	A	B	A	B	A *	B **	A	B	A	B	A	B	
32.1			49.8		4.1				209		222		248		241		136		166		
35.4			49.5		4.0				209		221		247		239		134		165		
36.3																					Sample Taken (Stage II-36.3 hrs.).
38.9			49.9		4.0				212		224		250		242		139		169		
44.3			50.5		4.0				210		222		248		240		134		167		
45.4																					Sample Taken (Stage II-45.4 hrs.).
49.1			49.9		4.0				212		224		250		242		139		170		
51.3			49.9		4.0				212		224		249		242		138		170		
54.3			49.6		4.0				212		224		249		242		139		170		
58.2			50.8		4.0				213		225		250		243		139		171		
60.2			49.9		4.0				211		223		248		241		137		170		
60.3																					Sample Taken (Stage II-60.3 hrs.).
60.3																					Manual Shutdown - Stage II Completed - Pump Inspected.
60.4																					Stage III - Test Start.
60.7																					Auto Shutdown (Reason Unknown).
60.7																					Test Restart.
60.9																					Sample Taken (Stage III-60.9 hrs.).
61.8			49.9		4.6				248		259		282		276		195		220		
63.6																					Bypass flow indication inoperative.
64.7			49.8		inop.				253		264		287	271	281		203		227		
65.9																					Bypass flow indication operative.
66.7																					Sample Taken (Stage III-66.7 hrs.).
67.7			49.7		4.5				253		264		287	271	281		203		227		
69.5			49.9		4.5				252		264		286	271	280		202		226		
70.8																					Auto Shutdown (Reason Unknown).
70.8																					Test Restart.
71.5					Manual Shutdown (Fluid overflow through relief valve in high pressure line).																
71.6																					Test Restart.
72.0																					Auto Shutdown (Reason Unknown).
72.0																					Test Restart.
73.3																					Manual Shutdown (Bad pump inlet temperature T/C).
73.3																					Test Restart.
			Opened pump for inspection. Looks good. Fixed both T/C leads.																		
74.8																					Test Restart.
75.0																					Auto Shutdown (Reason Unknown).
75.0																					Test Restart.
75.7			49.7		4.6				249		255		282	266	276		196		221		

* At pump case outlet.

** At pump case filter inlet (after case flow heat exchanger; before inlet to case filter).

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N : MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID:
Mil-H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Date	Time	Test Cell Temp. (F)	Test Hrs. (as on the counter)	Total Flow (Gallons)		Resrv. Fluid Level (mm)	Total Seal Leakage (ml)	Speed (RPM)		Torque (in-lbf)		Motor Current (amps)		Pressure Drop (PSI)						Pump Case Oulet Pressure (psig)	Pump Inlet Pressure (psig)		Pump Outlet Pressure (psig)	
														Main Filter 1		Case Filter Pressure (psi)		Case Filter						
				Main	Case			A	B	A	B	A	B	ΔΔ A	B	inlet	outlet	Δ A	B		A	B	A	B
30-Apr-93	1330	87	78.3	228822	19252	133.10	90	5230		1714		160		15		89	90	0			90		4119	
30-Apr-93	1400		78.8																					
30-Apr-93	1718	86	82.1	240198	20238	133.00	90	5230		1715		160		14		96	97	0			96		4124	
30-Apr-93	2100	83	85.8	251377	21202	133.00	100	5230		1715		160		15		96	97	0			97		4122	
30-Apr-93	2233	82	87.3	256039	21600	133.00	105	5230		1720		161		14		97	92	0			97		4122	
1-May-93	0137	81	90.4	265405	22396	132.94	110	5230		1737		162		15		97	98	0			97		4123	
1-May-93	0437	79	93.4	274524	23170	132.88	115	5230		1700		160		14		96	97	0		146	96		4121	
1-May-93	0500		93.8																					
1-May-93	0506		93.9	275877	23286																			

Δ Static Reading (Offset) During the Whole Test = -9.0 psi.
ΔΔ Static Reading (Offset) During the Whole Test = -6.0 psi.

PUMP TEST NO. 34

TEST PUMP : MODEL Vickers PV3-300-7B
S/N: MX 490651B

PUMP TEST DATA FOR AIRCRAFT HYDRAULIC FLUID
WL/MLBT, WPAFB PUMP TEST STAND NO. 1

TEST FLUID :
Mil- H-87257 (Royco)
MLO 92-11, MLO-92-142C

A= Throttling Valve Open
B= Throttling Valve Closed

Test Hrs.	Coolant Flow (GPM)		Flow Rate (GPM) Main		Flow Rate (GPM) Case		Flow Rate (GPM) Disk		Fluid Temperature (F) Pump Inlet		Fluid Temperature (F) Pump Outlet		Fluid Temperature (F) Case Drain		Fluid Temperature (F) TV Outlet		Coolant Temperature (F) Heat Exchanger Inlet		Coolant Temperature (F) Heat Exchanger Outlet		REMARKS
	A	B	A	B	A	B	A	B	A	B	A	B	A *	B **	A	B	A	B	A	B	
78.3			50.0		4.4				251		257		284	270	278		202		227		
78.8																					Sample Taken (Stage III-78.8 hrs.).
82.1			50.2		4.4				251		257		285	270	279		200		224		
85.8			50.2		4.4				253		259		286	271	281		202		226		
87.3			50.3		4.4				251		257		285	270	279		200		224		
90.4			50.8		4.4				253		258		286	271	280		202		226		
93.4			49.7		4.4				251		257		285	270	279		200		224		
93.8																					Sample Taken (Stage III-93.8 hrs.).
93.9																					Manual Shutdown - Stage III Completed - Pump Inspected.

* At pump case outlet.

** At pump case filter inlet (after case flow heat exchanger; before inlet to case filter).