SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION

by

W. L. Rhoads

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS3-6267 (PHASE II)

RESEARCH LABORATORY
SKF INDUSTRIES, INC.
ENGINEERING AND RESEARCH CENTER
KING OF PRUSSIA, PA.

NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the National Aeronautics and Space Administration (NASA), nor any person acting on behalf of NASA:

A) Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method of process disclosed in this report.

As used above, "person acting on behalf of NASA" includes any employee or contractor of NASA, or employee of such contractor, to the extent of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with NASA, or his employment with such contractor.

Requests for copies of this report should be referred to:

National Aeronautics and Space Administration
Office of Scientific and Technical Information
P. O. Box 33
College Park, Maryland 20740

NASA CR-72496
SKF AL68T074

SECOND PERIODICAL REPORT

ON

SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION

PHASE II

by

W. L. Rhoads

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

December 27, 1968

CONTRACT NAS3-6267

Project Management
NASA Lewis Research Center
Cleveland, Ohio 44135
Fluid Systems Component Division
William R. Loomis, Project Manager

RESEARCH LABORATORY
SKF INDUSTRIES, INC.
ENGINEERING AND RESEARCH CENTER
KING OF PRUSSIA, PA.

ACKNOWLEDGEMENT

Contributions to this program by the following members of the SKF Industries, Inc. Research Staff are acknowledged: G. Chiccarine, R. Evan, D. Hahn, H. Mahncke, L. Peacock, R. Pilkington, L. Rodrigo, A. Schwartz, L. Sibley.

TABLE OF CONTENTS

LIST OF ENCLOSURES

Enclosure

LIST OF ENCLOSURES (Cont'd)

Enclosure

18. Inner Race, Outer Race, Cage and Balls after 500°F Mobil Jet II Open Atmosphere Baseline Test

19. Air Seal, Air Seal Runner, Oil Seal, Oil Seal Runner after 500°F Mobil Jet II Open Atmosphere Baseline Test

20. Bearing Housing Bore after 500°F Mobil Jet II Open Atmosphere Baseline Test

21. Inner Race, Outer Race, Cage and Balls after 650°F Mobil XRM-109F, Mobil XRM-127B, and 10% by weight of Kendex 0839 Qualification Test

22. Air Seal, Air Seal Runner, Oil Seal, Oil Seal Runner after 650°F Mobil XRM-109F, Mobil XRM-127B and 10% by weight of Kendex 0839 Qualification Test

23, Bearing Housing Bore and Test Shaft after 650°F Mobil XRM-109F, Mobil XRM-127B and 10% by weight of Kendex 0839 Qualification Test.

REFERENCES

APPENDIX I - Summary Data Sheets for 50 Hour Task III Tests

AL68T074

SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION

by
W. L. Rhoads

ABSTRACT

Ball bearings and face seals for use on Mach 3 aircraft gas turbine engine mainshafts have been evaluated in tests of up to 50 hours duration using a recirculating system with jet lubrication under typical engine load and speed conditions with the seals exposed to 1200°F air and to a pressure differential of 100 psi.

Three lubricants were evaluated in these tests. Mobil Jet II ester (MIL-L-23699 specification) performed adequately at 500°F bearing temperature (400°F oil-in) without inert gas blanketing for 50 hours. Two synthetic hydrocarbon fluids tested with an inert gas blanket (Mobil XRM-109F plus 10% Kendex high-molecular-weight mineral-oil resin, and Mobil XRM-109F plus 10% Kendex resin plus Mobil XRM-127B blended to the same viscosity as XRM-109F) performed well at 650°F bearing temperature (500°F oil-in). The test with the blend of three fluids ran for the full 50 hours; however, system performance during the other hydrocarbon test was limited by oil seal failure after 32 hours. During the two full 50 hour tests a new oil seal design with piston-ring secondary seal and hydrodynamic gas-bearing primary sealing face was used with most encouraging results.

AL68T074

SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION

by

W. L. Rhoads

I. INTRODUCTION

This is the second periodical report under NASA Contract NAS3-6267, Phase II, and covers the Baseline and Qualifying Test portion of Task III of this contract.

The performance of aircraft gas turbine mainshaft ball bearings, seals, and lubricants under simulated (Mach 3) supersonic transport engine conditions is being studied using the most advanced materials, designs, and manufacturing techniques available. A recirculating system with jet lubrication which may be inert gas blanketed was used for all testing. Three lubricants, selected on the basis of results of testing in Task II of this Phase and in Phase I were run for up to 50 hours in the tests reported herein. These results will be used to assist in the selection of the two fluids to be used in endurance testing.

To recapitulate, in Phase I of this program, five advanced fluids were evaluated in the recirculating oil bearing-seal test rig, and five other fluids in a similar once-through (oil-mist) system, by running three-hour screening tests at bearing temperatures in the 600-800°F region. The most promising mist fluid and the two most promising recirculating fluids were then tested for longer periods of time. In Phase II, three additional fluids were screened in the recirculating-oil system in three -hour tests at bearing temperatures in the 550-700°F range (Task II). Based on the results of all screening tests, the three 50 hour tests reported herein were run with the most promising fluids in the recirculating-oil system. Using these results, two endurance tests of up to 250 hours duration will be conducted later (TASK III) in the recirculating-oil system.

II. SUMMARY AND CONCLUSIONS

In Phase II, both Task I (procurement and set-up of equipment) and Task II (screening tests) have been completed. Within Task III, one Baseline and two Qualifying tests have been completed. These Task III tests were run for up to 50 hours duration at specified test conditions in increments of no more than 10 hours continuous

running. The three lubricants evaluated were Mobil Jet II, an ester meeting the MIL-L-23699 specification; Mobil XRM-109F (synthetic paraffinic hydrocarbon) blended with 10% by weight of Kendex resin (highly refined, high molecular weight paraffinic resin); and a blend of Mobil XRM-109F, Mobil XRM-127B (less viscous version of XRM-109F) and 10% Kendex resin, in such quantity to give the blend the same bulk viscosity as Mobil XRM-109F. The baseline test used an M50 steel bearing (SKF 459981 G design) with a piston ring secondary oil seal and was run without inert gas blanketing. The qualifying tests were run using WB49 steel bearings (SKF 459980 H design) under an inert gas blanket with a variety of seal designs and materials.

The tests performed in this Task show the following:

1. Mobil Jet II ester performed adequately for 50 hours of open-atmosphere baseline testing at bearing temperatures of 500° to 530°F. Some surface distress was evident which may indicate this lubricant is marginal for long term operation in this temperature region. No evidence of bearing thermal instabilities were noted.

2. Mobil XRM-109F plus 10% Kendex resin performed well for 32 hours at 640° to 660°F bearing temperature using inert blanketing. Test termination was caused by oil seal failure. This fluid appears suitable for longer term operation at these conditions.

3. The blend of Mobil XRM-109F, Mobil XRM-127B and Kendex resin performed well for 50 hours under an inert blanket at 640° to 650°F bearing temperature. The suitability of this fluid for longer term operation at these conditions is doubtful. The viscosity of this blend was increased by 87% during the test, probably due to distillation of the lighter XRM-127B constituent.

4. With the proper selection of oil seal carbon, shoulder plating, face load, and oil cooling of the shoulder, it was possible to get sustained oil seal leakage rates of the order of 1 scfm without lift-off for over 32 hours with a bellows seal. This offers hope for longer trouble-free operation of this type of seal in future testing at the extreme conditions encountered in this program.

5. A new generation of oil seal employing a piston ring secondary seal (instead of metallic bellows) in conjunction with a shoulder having hydrodynamic lift pads has been successfully run for 100 hours without lift-off and is still considered operational. While this type of seal has minimum leakage rates 3 to 5 times that of the best bellows seal, it offers the best hope of extended testing for the remainder of the program.

III. TEST DETAILS

1. Background

In gas turbine engines designed for use in future generations of supersonic transport aircraft, the mainshaft thrust bearings and the seals used to contain the lubricant in the bearing chamber must be capable of operating at 600°F and above. Since lubricant degradation must be minimized for long term operation at these high temperatures, inert gas blanketing may be employed to reduce oxygen to a very low level in the bearing and lubricant system.

The current state of development of bearings, seals, and lubricants is such that short term operation under the conditions specified for advanced supersonic transport engines is possible. However, extended operation of candidate bearing-seal-lubricant systems, to be attempted in Task III of this effort, is needed to establish temperature limitations and system reliability.

Within this contract, the SKF Industries Research Laboratory has completed Phase I in which an inerted bearing-seal-lubricant system was used to test several lubricants under simulated supersonic jet engine conditions. The results of Phase I testing are summarized in (1).* In Phase I the most promising lubricant found was Mobil XRM 177F, which consists of the XRM 109F base-oil used in the present Phase II and a proprietary boundary lubricating additive of the organic-phosphate class.

2. Research Objectives

It is the purpose of Phase II of the program to perform additional investigations of the operational limits of the best currently available ball bearings, seals, and additional lubricants in a high temperature recirculating lubrication system under conditions simulating those expected in the main propulsion power units of an advanced Mach 3 supersonic transport aircraft. It is expected that this extended research will result in:

a) Data pertaining to the maximum temperature capabilities, up to 700°F outer race bearing temperature, of several promising lubricants not previously tested in a nitrogen blanketed recirculating lubrication system

*Numbers in parenthesis refer to references at the end of the text.

b) Operating experience with a modified bearing design (Series II) and new cage material and silver plating process.

c) Additional data on the behavior of bellows face seals and information on the performance of piston ring secondary face seals at extreme speed, temperature, and pressure differentials.

d) Longer-term performance (50 to 250 hours) data on bearing-seal-recirculating lubrication systems under simulated supersonic transport engine conditions with several of the most promising fluids found under Phase I and Task II, Phase II testing.

Of the above objectives the work so far completed has covered items a, b, c, and the 50 hour testing under d.

The remainder of this program, already in progress, will cover the operation of two fluids for periods of up to 250 hours.

The phasing of effort is shown in the Gant Chart in Enclosure 1, which is current as of November, 1968. Appendix 1 of (5) (Phase II - Scope of Work, Contract NAS3-6267) contains a detailed definition of the scope of the present effort.

3. Test Elements

The general plan of the test equipment used on this program is shown in Enclosure 2. An assembly drawing of the recirculating test rig is included as Enclosure 3. Detailed descriptions of the equipment and its capabilities have been given in (1,2,3,4).

a) Bearings

The test bearings used in this phase have been described in detail previously (1, 2, 3, 4, 5). Drawings of the two test bearings (459980H, WB49 steel and 459981G, M50 steel) are shown in Enclosures 4 and 5. The ion silver plated 4340 steel cage used in all extended testing is shown in Enclosure 6.

b) Seals

The dual test seal arrangement used in all testing to date

has been described in detail in (1,2,3,4,5). In several of the long term tests reported herein a new design face seal employing a carbon piston ring secondary in place of the previously utilized steel bellows secondary has been used (with good success). In addition to the different secondary sealing arrangement, the shoulder incorporates hydrodynamic lift pads. The piston ring seal is shown in Enclosure 7 and the hydrodynamic lift pad shoulder is shown in Enclosure 8. Bellows oil and air seals and shoulders are shown in Enclosures 9, 10 and 11.

c) Lubricants

Data for Mobil Jet II and Mobil XRM-109F plus 10% Kendex 0839 high molecular weight resin have been presented in (5). The third fluid tested in this Task consisted of the blend of XRM-109F plus 10% Kendex resin with enough (approximately 10%) Mobil XRM-127B added to bring the bulk viscosity of this blend down to approximately the viscosity of XRM-109F (442.6 cs @ 100°F). This was done to insure that the good performance of the blend tested in Task II was due to the additive effect of the Kendex resin and not to the (relatively small) bulk viscosity increase of the test fluid.

Mobil XRM-127B is a synthetic hydrocarbon of the same chemical family as XRM-109F, but with a viscosity of 62.7 cs @ 100°F.

IV. TEST RESULTS

The three nominal 50 hour tests conducted under Task III are reported in chronological order. All testing was conducted in increments of no more than 10 hours at specified conditions with a cool down to a bearing outer ring temperature of 200°F before restart of the next increment.

A Summary of these test results is presented in Enclosure 12. Enclosure 13 summarizes acid number and viscosity data for these tests. Enclosure 14 tabulates test elements used in each test. A summary of test parameters is presented in Appendix I.

1. Qualifying Test No. 1-Mobil XRM-109F Plus 10% Kendex Resin

The first of two specified qualifying tests was run using Mobil XRM-109F hydrocarbon plus 10% (by weight) of Kendex 0839 resin, a WB49 steel test bearing with an ion silver plated 4340 steel cage, and an oil seal with AM350 steel bellows, CDJ83 carbon, and a chromium-carbide plated shoulder modified for oil

cooling. An Inco 718 bellows air seal with CDJ83 carbon was used for the first 31 hours of testing while a seal having AM350 steel bellows and 56HT carbon was used for the last 1.3 hours. A chromium-carbide plated air seal shoulder was used throughout.

This test was run for a total of 32.3 hours at 640° to 660°F bearing outer ring temperature, which was accumulated in three 10-hour, one 1-hour, and one 1.3-hour increments. Oil inlet temperature varied between 490° and 525°F. (An additional 5.6 hours was accumulated at outer ring temperatures between 600° and 640°F). The inner ring ran between the outer ring temperature and 50°F above the outer ring. Some "I" housing heat and shaft cooling was required at various points during the test. Oil flow was varied between 0.8 and 2 gpm to control test bearing temperature, with most of the test operating at 1.25 gpm.

The first thirty hours were run without incident with all components performing flawlessly. The total seal leakage was in the 1 to 3 scfm range, approximately split equally between both test seals.

During the cool down after the third 10-hour increment, the oil seal lifted off and the oil charge was lost. The oil seal could not be reseated without disassembling the rig. During this disassembly it was noted that the oil seal runner was being grooved by the carbon and that the air seal carbon exposed to the hot air was being eroded. The rig was re-started and ran for 1-hour at conditions before heater failures forced another shut down and disassembly. During this time it was found that the air seal carbon had eroded to the point where it was not considered serviceable and it was replaced with a back-up seal with 56HT carbon. The rig was assembled and re-started several more times (with difficulty due to initial oil seal leakage) and an additional 1.3-hours at test conditions accumulated before another disassembly was required because the oil seal blew open and would not seat. During this disassembly it was noted that the oil seal shoulder showed signs of "chatter" in the groove (0.002 to 0.003 inches deep) worn by the carbon. Because of the difficulty experienced in obtaining the last few hours of running at test conditions and because of the condition of the oil seal, the test was terminated since it was not considered that the oil seal was serviceable any longer. The test bearing was found to be in very good condition with signs of very slight glazing in the ball paths and light cage pocket wear. The air seal shoulder was in good condition.

The Mobil XRM-109F plus Kendex resin lubricant is considered suitable for further, longer-term testing in this temperature region. Enclosures 15 through 17 present photographs of test elements from this run.

2. Baseline Test - Mobil Jet II Ester

An open atmosphere baseline test was run using Mobil Jet II ester oil and an M50 steel bearing with an ion silver plated 4340 steel cage. A new oil seal with a carbon piston ring secondary and CDJ83 primary carbon face and with a tungsten carbide plated shoulder incorporating a hydrodynamic lift pad design was used. The air seal had an AM350 steel bellows, 56HT carbon face and a chromium-carbide plated shoulder.

The test was run at 500° to 535°F outer ring temperature for a total of 50 hours which was accumulated in three 10-hour, one 9.6-hour, one 7.6-hour, one 2.5-hour and one 1-hour increments, as explained below. The oil inlet temperature ranged from 390° to 420°F while the inner ring temperature was about the same as the outer ring temperature to help control the outer ring. The test oil flow was 2 gpm during the entire test.

During the 1st hour of testing two shut downs occurred due to shear pin breakage. After the second shut down the test was re-started with pins of a slightly different design (increased shoulder radius and a slightly larger cross section) and continued to run for 9.6-hours before a manual shut down was performed as a result of an unusual noise coming from the test rig. The rig was completely disassembled and the test bearing and the support bearing examined. This examination showed nothing at fault and the test was re-started and run for 10 hours without incident at which time the rig was shut down for the weekend.

The test was re-started and run for 7.6 - hours when a shear pin breakage again shut the test down. After a 25 minute delay the test was re-started and the remaining 2.4-hours of the 10-hour period was completed. The remaining two 10-hour periods were run without incident.

During the first 3-hours of testing the total seal leakage was about 10 scfm. During the remainder of the test the total seal leakage was 3.8 to 6.8 scfm.

Upon disassembly the test bearing was found to have some slight surface distress on the inner and outer ring accompanied by heavy ball contact in the cage pockets as well as evidence of cage land contact on about 90° of the circumference. The oil left some deposits on the bore of the test bearing housing. All sealing elements were found to be in excellent condition with 0.003" carbon wear on each seal. The shear pin breakage suggests higher than normal power loss in this test, presumably from lubricant shearing at the bearing or seal contacts and not bulk viscous drag, since the bulk viscosity of this oil is not excessively high. Enclosures 18 through 20 present photographs of test elements from this run.

3. Qualifying Test No. 2 - Mobil XRM-109F, XRM-127B, plus 10% Kendex 0839 Resin

The second specified qualifying test was run at 640° to 650°F outer ring temperature with an inner ring temperature about equal to or 10°F hotter than the outer ring. The oil inlet temperature was 500° to 520°F and the oil flow was 1.5 to 2.0 gpm.

The test ran a total of 50-hours in four 10-hour, one 6-hour, and one 4-hour increment as will be explained. After starting the test it took 2.7 hours to reach the desired outer ring temperature of 650°F with 13 amps current drawing on both "I" housing heaters. Before any appreciable time could be logged at test condition one of the "I" housing heaters failed causing the outer ring temperature to drop to 600°F necessitating a shut down to replace the failed heater.

Because of the difficulty in reaching and maintaining test conditions, additional insulation was obtained and wrapped around the outside of the test rig housing. When the test was re-started test conditions were reached within 1.1 hours and less than 5 amps of "I" housing heat was required to maintain temperature. Three 10-hour periods were logged before the weekend shutdown. The test was re-started and run for 6 hours. The nitrogen supply pipe to the seal cavity broke causing a sudden decrease in seal cavity pressure. The rig was shut down and the pipe repaired. The test was restarted after a 7-hour delay and run for a 10-hour and 4-hour period to time-up.

During the first 36 hours of testing prior to the breaking of the nitrogen supply line the total seal leakage was 9.4 to 13.5 scfm. After the line breakage it increased to 19.5 to 29.8 scfm. The mass spectrometer showed that during the first 36 hours most of

leakage was about evenly divided between the air and oil seals.

Upon disassembly the test bearing was found to be in very good condition. Both the oil and air seals were in good condition. The oil seal carbon wear was negligible while the air seal carbon had worn 0.005," probably as a result of the high pressure differential acting on this seal when the seal pressure was lost. The shoulders of both seals were in good condition with some chatter marks evident on the air seal shoulder.

Some oil deposits were found in the bearing cavity and on the unloaded half of the bearing inner ring. Photographs documenting this test are presented in Enclosures 21 through 23.

V. DISCUSSION

1. Test Bearings

Since there is only one oil, Mobil XRM-177F, common to both Phase I and Phase II testing, the comparison between the heat generation of Series I design bearings, used in Phase I, and Series II bearings, used in Phase II, will be examined when the endurance test with this fluid is discussed in the Final Report. Also, since most tests were successful in this Phase, as opposed to numerous smearing failures encountered in Phase I, it is rather difficult to compare the performance of the electroplated M-1 steel cages with that of the ion silver plated 4340 cages used in this phase. It does appear, however, based on the quantitative results to date, that the ion plating is at least as good as the electroplating. There is no discernible difference in cage material performance in these tests.

2. Test Seals

It appears that by utilizing a face load (0.4 lbs./in of circumference) heavy enough to prevent lift-off in conjunction with wear-resistant carbon and shoulder plating, leakage rates on the order of 1 scfm for up to 32 hours can be achieved using bellows secondary oil seals. This is a decided improvement over previous results and can probably be improved upon further by the use of a harder shoulder plate since the present failure mode of these seals is excessive wear of the shoulder plating. The most promising oil seal tested is the piston ring secondary with a

A R100

shoulder employing hydrodynamic lift pads. One of these seals has been run for two 50-hour tests and is still considered serviceable, although the minimum leakage rate obtained with this type of seal is 3 to 5 times that seen with a properly functioning bellows seal. It may be possible to combine certain features of the two types and employ a bellows secondary with hydrodynamic lift shoulder for reliable low-leakage performance in the future.

The bellows air seal remains essentially trouble-free. It is thought that the erosion of the CDJ 83 carbon in the First Qualifying Test which was of such magnitude that the inner wear pads were completely removed and the sealing dam reduced to a knife-edge, was caused by oxidation of the binder used when exposed to the hot air for extended periods. (This seal was utilized for over 60 hours at various test conditions.)

A discussion of all seal experience and results to date is presented in (6).

3. Viscosity Increase of Blend of Mobil XRM-109F, XRM-127B, and Kendex Resin

Viscosity of this blend used in the second qualifying test increased by roughly 87% during the course of the 50 hour run. This is very likely caused by distillation of light ends of the XRM-127B at the test temperature, since the loss of this more volatile material would lead to a rise of the viscosity in the residue. Samples taken from the vent line indicated that oil lost through this line was of a low viscosity. The combination of bearing test chamber and vent pipe geometry does constitute a crude fractional still so that part of the material volatilized from the bearing test chamber was returned to the chamber by condensation through the vent pipe, but a large part of it escaped. Since the XRM-127B is much lighter than the XRM-109F, the proportion lost by distillation would be somewhat greater.

In addition, there are indications that some thermal degradation of the hydrocarbon material had occurred. This would lead to formation of volatile products which would escape through the vent pipe, while some of the residue would probably react with other residues to form even more viscous materials. Some

evidence of this phenomenon was found in the mass spectra scans which were taken on an earlier experiment with XRM-177F and reported in (4). Up to the present, no mass scans have been made of the current mixture under test, but it is planned to follow these effects during the next run.

Discussions of this point with the supplier of the XRM materials has elicited agreement with the above mechanisms proposed for the observed viscosity increase. It is to be noted also that there has been no increase in acid number of the lubricants during this test. Thus, a viscosity increase of the lubricant due to oxidation was not likely.

4. Overall Outlook

Mobil Jet II ester performed adequately in open-atmosphere testing for 50-hours at bearing temperatures in the 500° to 530°F range. Evidence of slight surface distress of bearing ring surfaces indicates however, that this lubricant is marginal for long-term operation in this temperature region in the test rig used.

Mobil XRM-109F plus Kendex resin and Mobil XRM-109F plus XRM-127B plus Kendex resin both performed well for 50 hours with inert blanketing at temperatures in the 650°F region and are considered suitable for longer term (endurance) testing at these conditions. Because of the great increase in viscosity of the blend containing Mobil XRM-127B and the relatively small bulk viscosity increase of the Mobil XRM-109F plus Kendex resin over Mobil XRM-177F, it is recommended that the XRM-109F plus resin fluid blend be tested in the second 250-hour endurance run. Based on good performance in other reported testing on this program, Mobil XRM-177F was chosen as the first endurance test fluid.

The program has progressed to the point where adequate seals, lubricants, and test bearing specimens should permit reliable endurance type system testing.

typed: mlj

REFERENCES

1. Hingley, C.G., et al "Supersonic Transport Lubrication System Investigation", Semiannual Report No. 1, NASA CR-54311, SKF AL65T038, (1965).

2. Hingley C.G., and Sibley, L.B., "Supersonic Transport Lubrication System Investigation", Semiannual Report No. 2, NASA CR-54312, SKF AL65T077, (1965).

3. Rhoads, W.L. and Sibley L.B., "Supersonic Transport Lubrication System Investigation", Semiannual Report No. 3, NASA CR-54313, SKF AL66T032, (1966).

4. Rhoads W.L. and Sibley L.B., "Supersonic Transport Lubrication System Investigation", Final Report on Phase I of NASA Contract NAS3-6267, NASA CR-54662, SKF Report AL67T060, (1968).

5. Rhoads W.L., "Supersonic Transport Lubrication System Investigation", First Periodical Report on Phase II of NASA Contract NAS3-6267, NASA CR-72424, SKF Report AL68T046, (1968).

6. Rhoads W.L., "Supersonic Transport Lubrication System Investigation, Phase II Supplemental Seals Report, NASA Contract NAS3-6267, SKF Report AL68T102, to be published.

Contract NAS3-6267 Progress Report Period March 7 through Nov. 29, 1968
Title SST Lubrication System Investigation
Contractor SKF Industries, Inc.
Prepared by G. Chiccarine Date 11/29/68
G. Chiccarine

NASA

ENCLOSURE 1

CONTRACT PROGRESS SCHEDULE

Reporting Category (Task/Milestone/Approval)	SCHEDULE O-O PROGRESS △-△ ACT.-START △//△ 1967 J A S O N D / 1968 J F M A M J J A S O N D / 1969 J F M A M J	WEIGHT FACTOR	% COMP.	CONTR. COMP.	NASA INTERNAL USE
TASK I Rig & Test Bearings Seals & Fluid Selection		(20)			
Bearing Procurement		10	100	10.0	
Seal Procurement		10	100	10.0	
Task II Screening Tests		(25)			
First Fluid		9	100	9.0	
Second Fluid		8	100	8.0	
Third Fluid		8	100	8.0	
Submission of Draft of First Periodical Report (Task I & II)		0			
Approval of First Periodical Report		1	100	1.0	
Distribution of First Periodical Report		1	100	1.0	
TASK III Baseline Tests		5	100	5.0	
Qualifying Tests #1		5	100	5.0	

(1) Rescheduled as described in Monthly Progress Report No. 5

RESEARCH LABORATORY SKF INDUSTRIES, INC.

AL68T074

Contract NAS3-6267 Progress Report Period March 7 through Nov. 29, 1968
Title SST Lubrication System Investigation
Contractor SKF Industries, Inc.
Prepared by J. Chiccarine Date 11/29/68
J. Chiccarine

ENCLOSURE 1 (CONT'D)
CONTRACT PROGRESS SCHEDULE

NASA

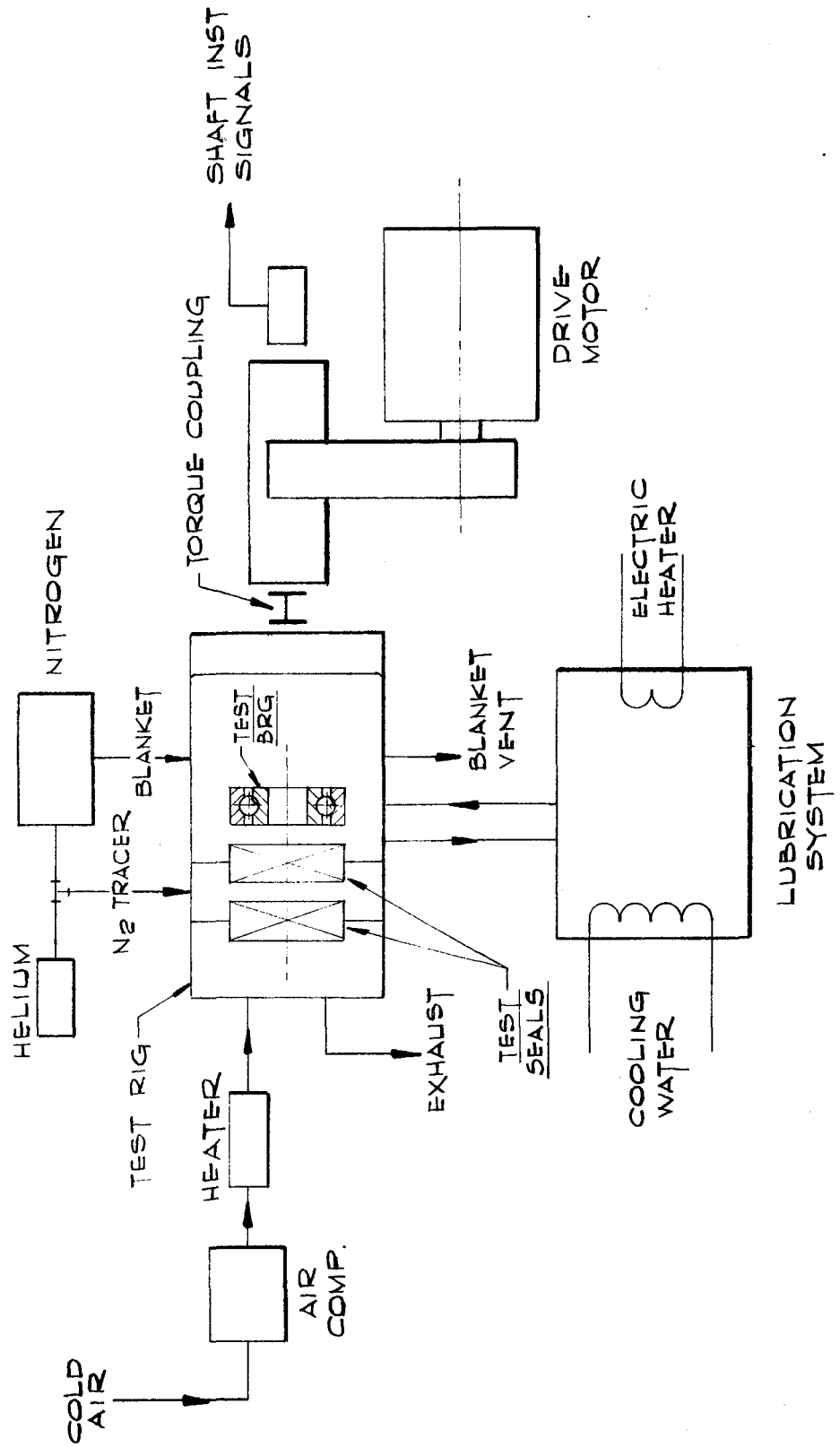
Reporting Category (Task/Milestone/Approval)	Weight Factor	% Comp.	Contr. Comp.	NASA Interim Use
Qualifying Tests #2	5	100	5.0	
Submission of Draft of Second Periodical Report (Task III A & B)	0			
Approval of Second Periodical Report	1			
Distribution of Second Periodical Report	2			
250 Hour Endurance Test No. 1	15	100	15.0	
250 Hour Endurance Test No. 2	15			
Monthly Progress Reports	0			
Submission of Draft of Final Report	0			
Approval of Final Report	2			
Distribution of Final Report	3			

(2) Rescheduled as described in Monthly Progress Report No. 15

AL68T074

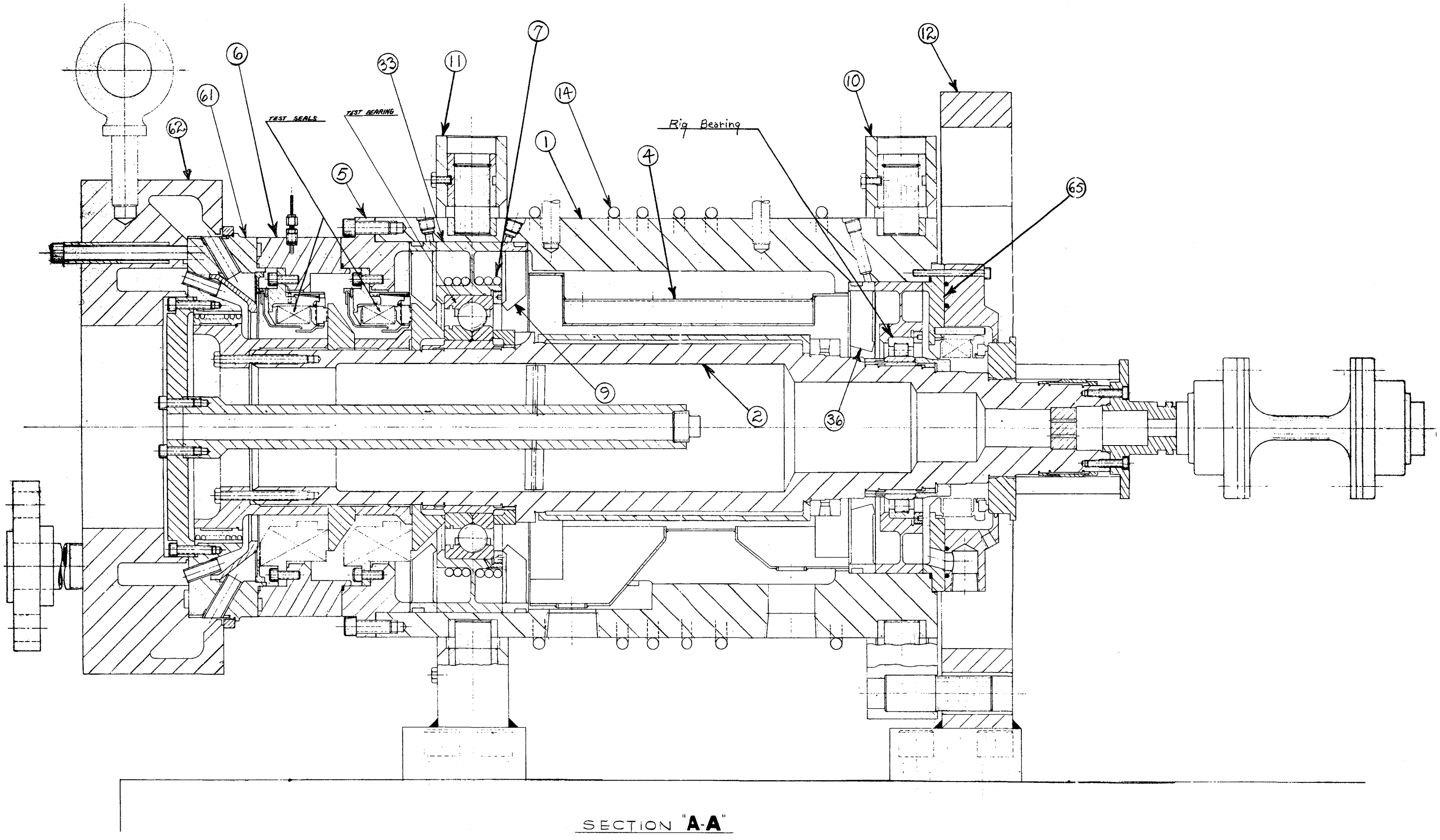
ENCLOSURE 2

GENERAL TEST RIG LAYOUT SCHEMATIC



ENCLOSURE 3

TEST RIG ASSEMBLY



SECTION "A-A"

76272-2

SKF

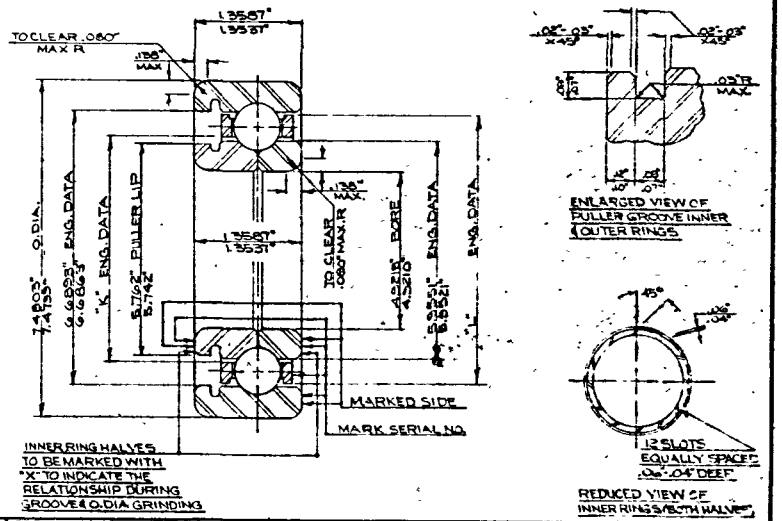
		459980 H	459980 J ①	459980 K ①	459981 E ①	459981 F ①
1	VENDORS PART NO.	459980 H	459980 J	459980 K	459981 E	459981 F
2	VENDORS NAME PLATE	76272-2	76272-2	76272-2	76272-2	76272-2
3	BEARING TOLERANCE	ABEC 7	ABEC 7	ABEC 7	ABEC 7	ABEC 7
4	NO & SIZE OF BALLS	21-13/16 DIA.	21-13/16" DIA.	21-13/16" DIA.	21-13/16" DIA.	21-13/16" DIA.
5	INTERNAL RADIAL CLEARANCE (MOUNTED)	.0097"-.0109"	.0085"-.0097"	.0081"-.0099"	.0068"-.0080"	.0068"-.0080"
6	END PLAY (MOUNTED)	.035"	.032"	.029"	.029"	.029"
7	CONTACT ANGLE	31°30'-35°30'	32°30'-36°30'	32°30'-36°30'	29°30'-33°30'	29°30'-33°30'
8	OUTER GROOVE RADIUS AS PERCENT OF BALL DIA.	51.50-51.75	52.00-52.25	52.00-52.25	52.00-52.25	52.00-52.25
9	INNER GROOVE RADIUS AS PERCENT OF BALL DIA.	52.75-53.00	51.50-51.75	51.50-51.75	51.50-51.75	51.50-51.75
	SHIFT	.013"	.009"	.009"	.009"	.009"
	PITCH DIA.	6.280"	6.280"	6.280"	6.280"	6.280"
2	CAGE WIDTH (MAX)	1.024"	1.024"	1.024"	1.024"	1.024"
3	CAGE SPEC (FOR OUT-OF-ROUNDNESS & SQUARENESS)	470939	470939	470939	470939	470939
4	CAGE POCKET CLEARANCE	.009"-.017"	.014"-.022"	.009"-.017"	.014"-.022"	.009"-.017"
15	BALL GRADE (AFBMA)	15	15	15	15	15
16	INNER RING MATERIAL	WB 49	WB 49	WB 49	M50	M50
17	OUTER RING MATERIAL	WB 49	WB 49	WB 49	M50	M50
18	BALL MATERIAL	M-1	M-1	M1	M50	M50
19	CAGE MATERIAL	M-1	M-1	M1	M1	M1
20	CAGE TYPE	ONE PIECE MACHINED OUTER LAND RIDING	ONE PIECE MACHINED OUTER LAND RIDING	ONE PIECE MACHINED OUTER LAND RIDING	ONE PIECE MACHINED OUTER LAND RIDING	ONE PIECE MACHINED OUTER LAND RIDING
21	BEARING DESIGNED TO OPERATE AT (MAX)	850°	650°	850°	850°	650°
22	INNER RING HARDNESS	67 MIN	61 MIN	67 MIN.	67 MIN.	61 MIN.
23	OUTER RING HARDNESS	67 MIN	61 MIN	67 MIN.	67 MIN.	61 MIN.
24	BALL HARDNESS	62 MIN	62 MIN	62 MIN.	62 MIN.	62 MIN.
25	CAGE HARDNESS	53 MIN	53 MIN	53 MIN.	53 MIN.	53 MIN.
26	CAGE RUNNING CLEARANCE ON DIA	.010"-.020"	.010"-.020"	.010"-.020"	.010"-.020"	.010"-.020"
27	CAGE O DIA "J"	6.681"-6.673"	6.681"-6.673"	6.681"-6.673"	6.681"-6.673"	6.681"-6.673"
28	CAGE I DIA "K"	6.111"-6.121"	6.111"-6.121"	6.111"-6.121"	6.111"-6.121"	6.111"-6.121"
29	CAGE PLATING TYPE	SILVER AMS 2410	SILVER AMS 2410	SILVER AMS 2410	SILVER AMS 2410	SILVER AMS 2410
	CAGE PLATING THICKNESS	.001"-.002"	.001"-.002"	.001"-.002"	.001"-.002"	.001"-.002"

CAGE TO BE 100% FLUORESCENT PENETRANT INSPECTED (470908)
100% DUAL INSPECTION (470663)
100% MAGNAFLUX INSPECTED ON (471682)
100% ETCH INSPECTION (471637)
MATERIAL AND IDENTIFICATION CONTROL AS PER SPEC 471085
INNER RING, OUTER RING AND BALLS TO BE BLACK OXIDE TREATED
AS PER AMS 2485

SURFACE FINISH REQUIREMENTS

		RMS	MAX
INNER RING BORE	16	"	"
INNER RING GROOVE	4	"	"
OUTER RING O.DIA.	16	"	"
OUTER RING GROOVE	4	"	"
CAGE SUPPORT SURFACE	20	"	"
BALL	12	"	"
OUTER RING BORE	4	"	"
INNER RING O.DIA.	4	"	"

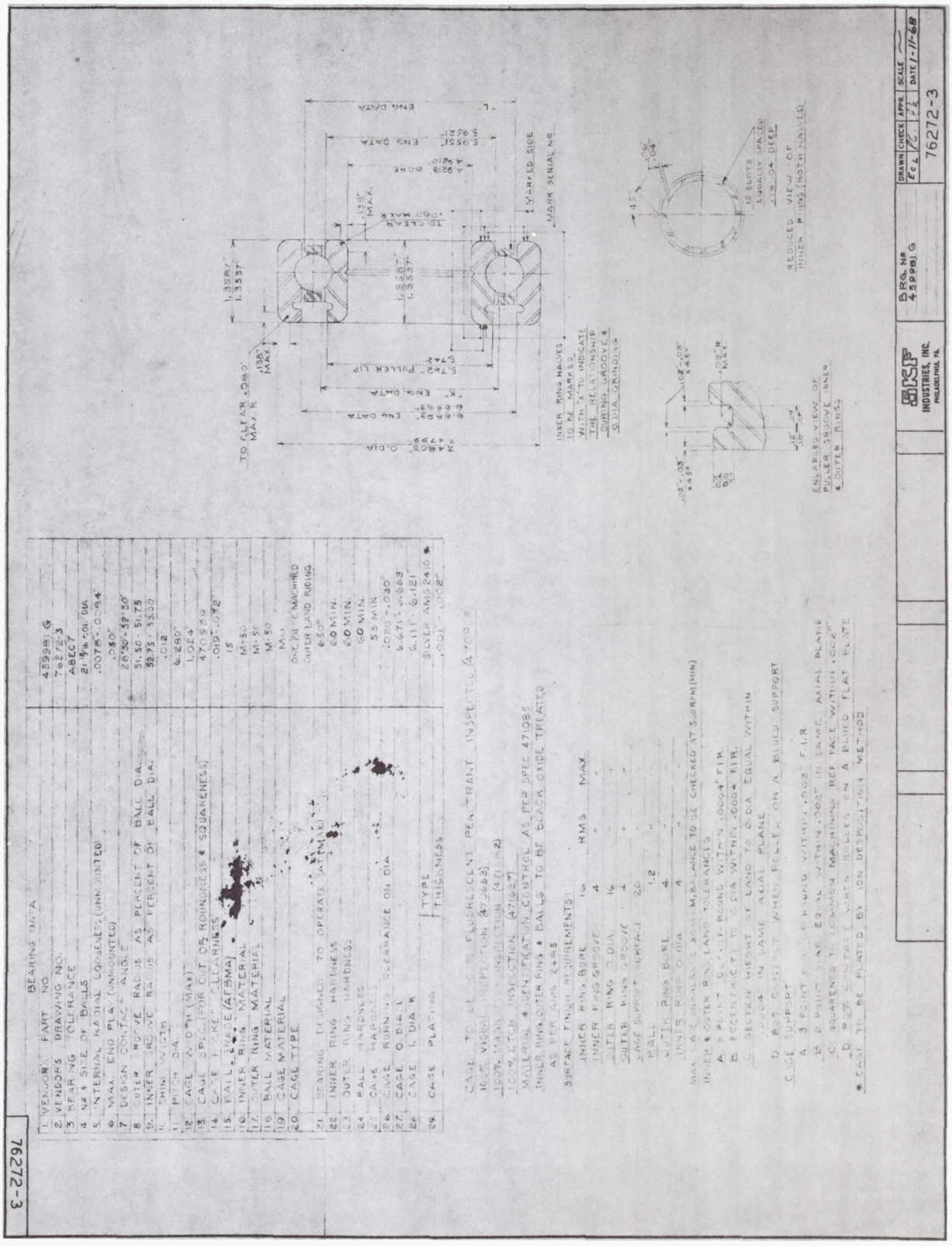
MAX CAGE UNBALANCE 3GM-CM, BALANCE TO BE CHECKED AT 500 RPM (MIN)
INNER & OUTER RING LAND TOLERANCES
A. 3 POINT OUT-OF-ROUND WITHIN .0004" F.I.R.
B. ECCENTRICITY TO O.DIA WITHIN .0004" F.I.R.
C. SECTION HEIGHT OF LAND TO O DIA. EQUAL WITHIN .0004" IN SAME AXIAL PLANE
D. 80% CONTACT WHEN ROLLED ON A BLUED SUPPORT
CAGE SUPPORT
A. 3 POINT OUT-OF-ROUND WITHIN .003" F.I.R.
B. 2 POINT DIAMETERS EQUAL WITHIN .002" IN SAME AXIAL PLANE
C. SQUARENESS TO COMMON MACHINING REF FACE WITHIN .002"
D. 80% CONTACT WHEN ROLLED ON BLUED FLAT PLATE



			ADDED SIZES ED 9-24-64	SKF INDUSTRIES, INC. PHILADELPHIA, PA.	BRG NO 459920 H, J, K; 459981 D, E, F	DRAWN A.M. CHECK APPR. SCALE F.K. DATE 9-3-65
						76272-2

ENCLOSURE 5

459981 G BEARING DESIGN DATA



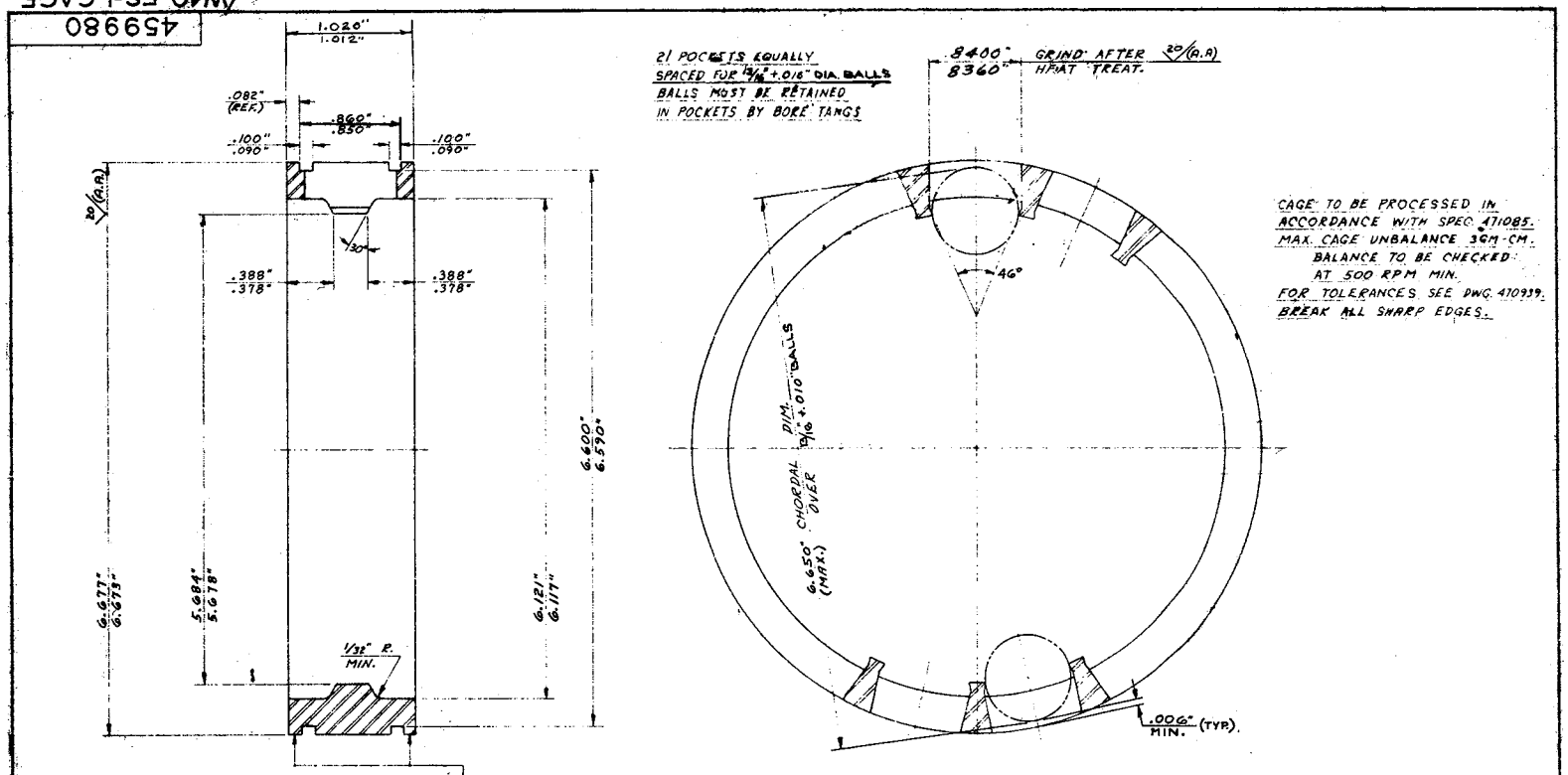
RESEARCH LABORATORY SKF INDUSTRIES, INC.

ENCLOSURE 6

459980 FS-1 CAGE

AL68T074

459980 /W40 FS-1 CAGE



CAGE TO BE PROCESSED IN ACCORDANCE WITH SPEC. 471085.
MAX. CAGE UNBALANCE 3GM-CM.
BALANCE TO BE CHECKED AT 500 RPM MIN.
FOR TOLERANCES SEE DWG. 470939.
BREAK ALL SHARP EDGES.

3 POINT OUT-OF-ROUND OF THESE LAND RIDING SURFACES TO BE WITHIN .003" F.I.R. THESE LAND RIDING DIA.'S TO BE EQUAL WITHIN .002" (2 PT. MEASUREMENT) IN THE SAME AXIAL PLANE. SQUARENESS OF EACH OF THESE LAND RIDING SURFACES TO COMMON MACH. REF. FACE TO BE WITHIN .002". THESE LAND RIDING SURFACES TO BE FLAT & SHOW 80% CONTACT WHEN ROLLED ON A BLUED FLAT PLATE.

MATERIAL:- STEEL AS PER SPEC. 471711
HEAT TREAT PRIOR TO GRINDING & POLISHING AS PER SPEC. 471466

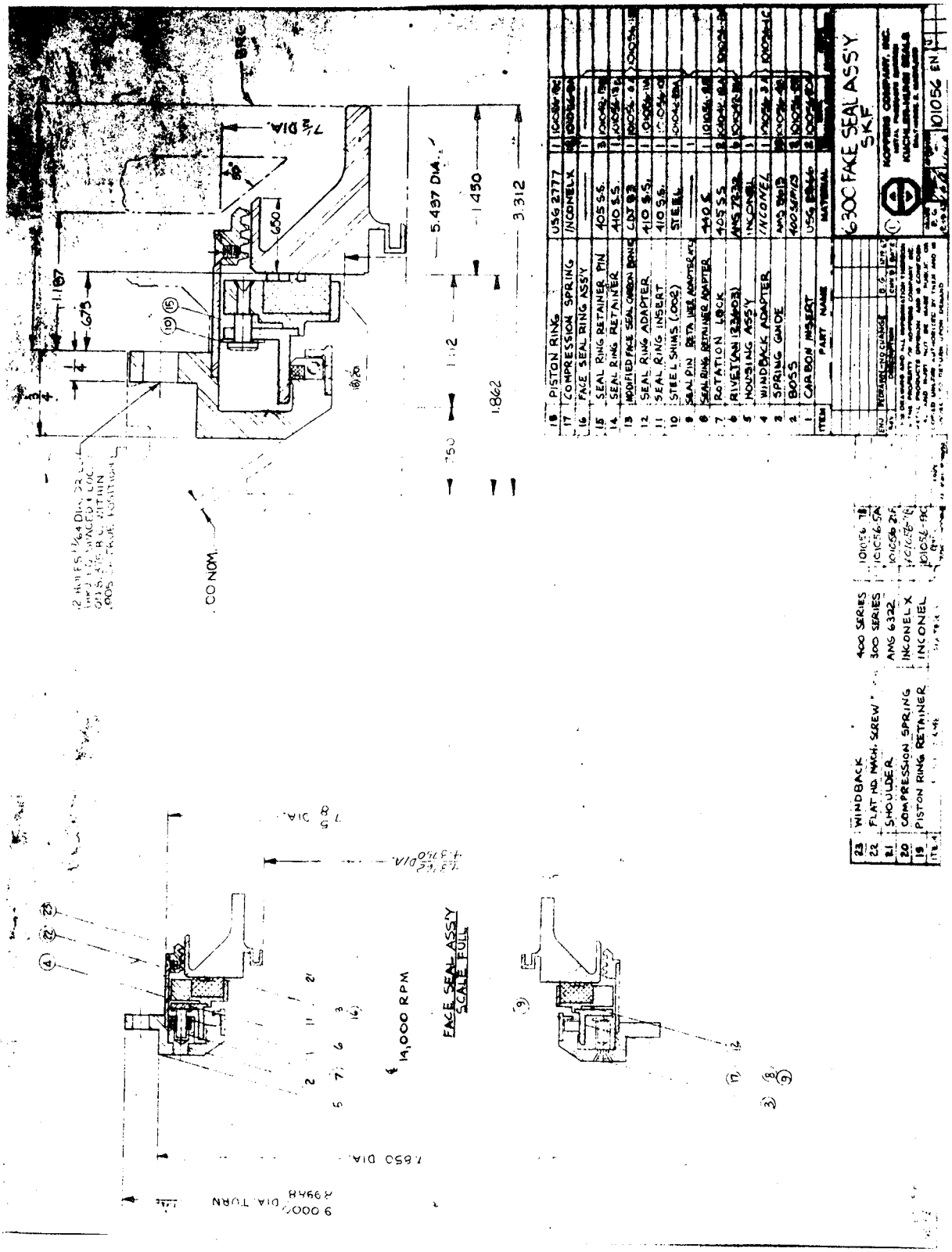
SILVER PLATING TO BE DONE BY ION DEPOSITION METHOD BY A SUB-CONTRACTOR. BALANCING WILL BE DONE AFTER PLATING

				SKF INDUSTRIES, INC. PHILADELPHIA, PA.	459980/W40 FS-1 CAGE	DRAWN	CHECK	APPR.	SCALE
						G.J.K.	E.K.	EK/WB	DATE 5-22-67

459980
/W40 FS-1 CAGE

ENCLOSURE 7

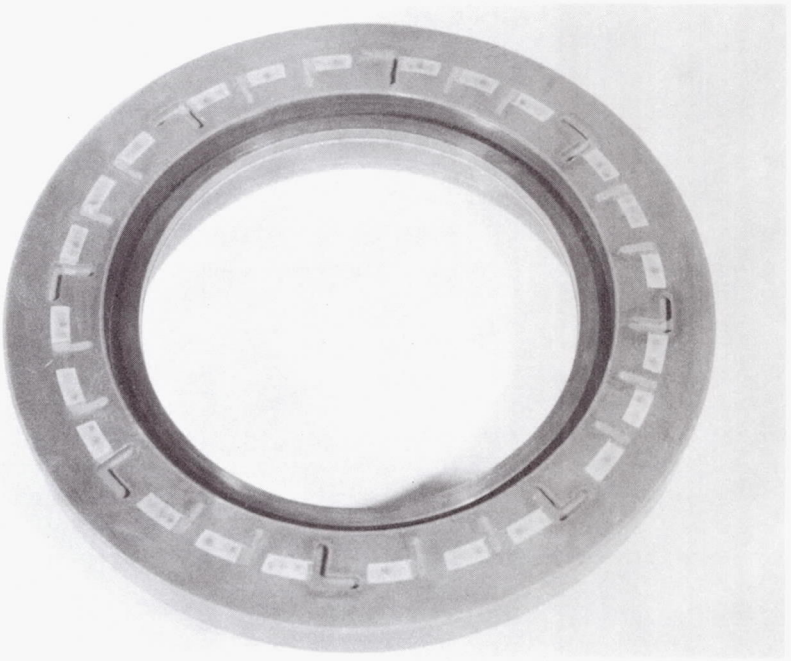
PISTON TYPE OIL SEAL DESIGN

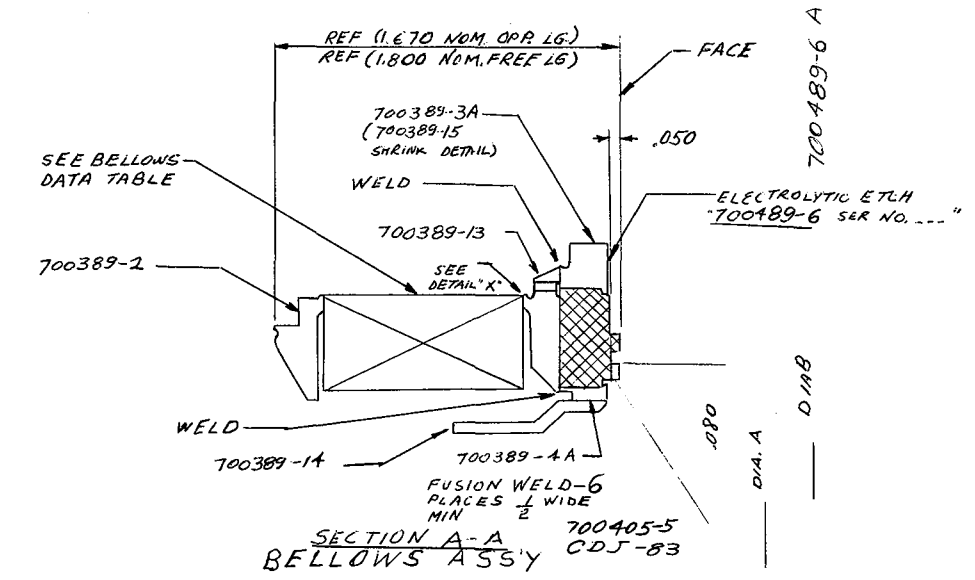


AL68T074

ENCLOSURE 8

HYDRODYNAMIC LIFT DESIGN OIL SEAL SHOULDER



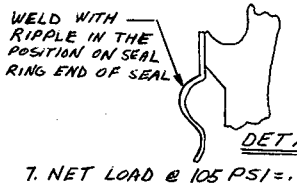


SECTION A-A
BELLOWS ASS'Y

BELLOWS DATA	
DIE NO.	KB 115
BELLOWS O.D.	6.830
BELLOWS I.D.	5.830
THICKNESS	.006
HEAT TREAT BELLOWS PITCH	.075
NO CONVOLUTIONS	14
SCALE	
FREE LENGTH	1.050
OPERATING LENGTH	.920
Δ	.130
LOAD (MEASURED)	16 #
SOLID LENGTH	.452
MATERIAL	AM-350

SEE NOTE #1

18 RELIEFS 1/8 DIA. WHEEL X .050 DEEP X 5/16 WIDE EQ. SPACED & LOC. AS SHOWN



DETAIL X

7. NET LOAD @ 105 PSI = .554/IN.
6. λ = FOR OUTWARD FLOW
5. DIA'S "A" & "B" TO BE DETERMINED BY ENGR. AFTER TEST, CUT TRIAL DAM (DETAIL DWG 700389-16 BALANCE TEST FIXTURE 600532)
4. FACE "C" LAPPED FLAT WITHIN 2 BANDS (HELIUM LIGHT)
3. DIAS "A" & "B" TO BE CONCENTRIC WITHIN .001 F.I.R. & SQUARE WITH FACE (WITHIN .0016 F.I.R.
2. USE STANDARD HEAT TREAT PROCEDURE EXCEPT USE 1100°F. DRAW TEMPER INSTEAD OF 850°F
1. KB 115 DIE PITCH .085
NOTE:

SCALE - FULL

BELLOWS ASSEMBLY
(OIL SIDE)

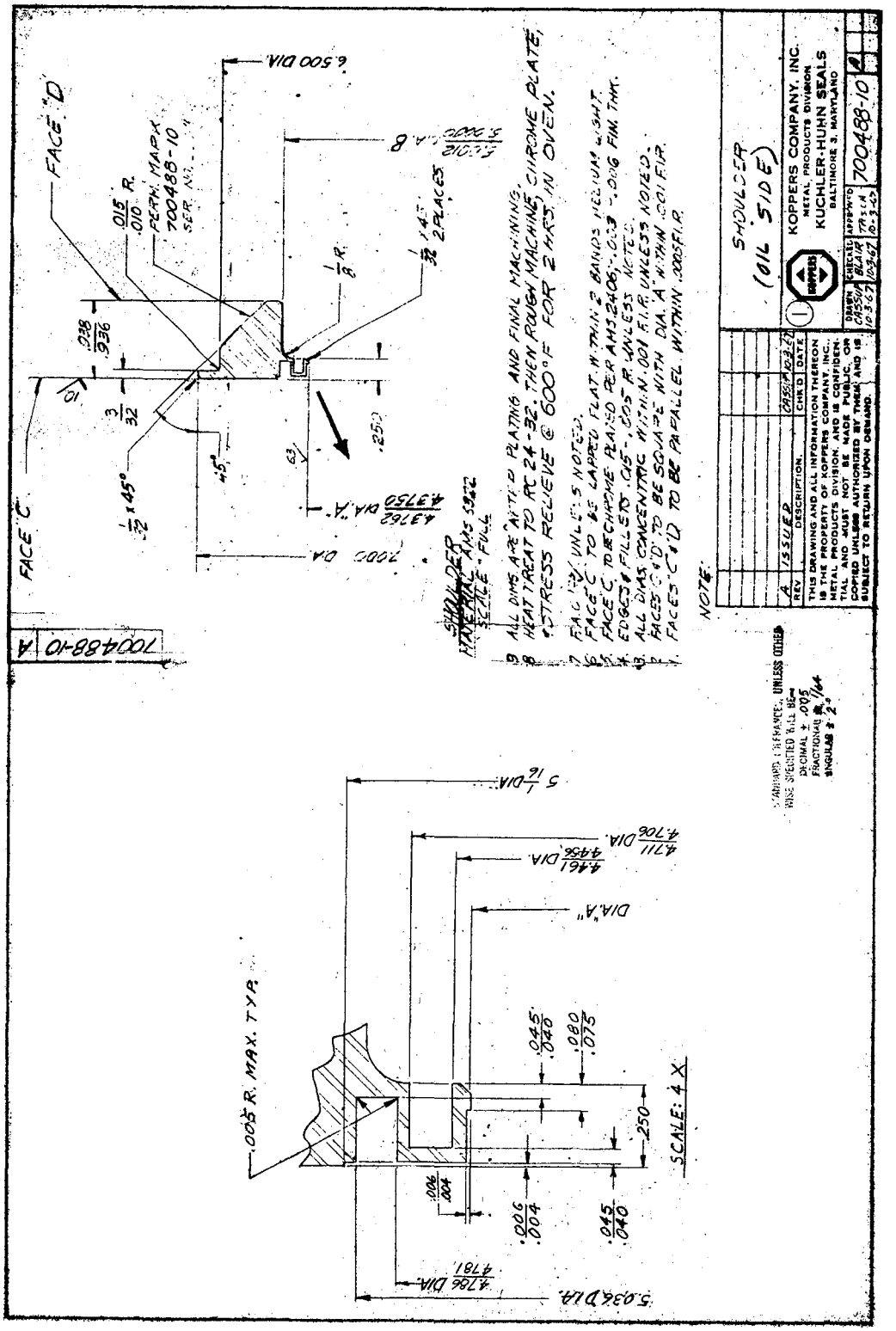
KOPPERS COMPANY INC.

700489 6

AL68T074

ENCLOSURE 10

BASIC BELLOWS OIL SEAL SHOULDER DESIGN

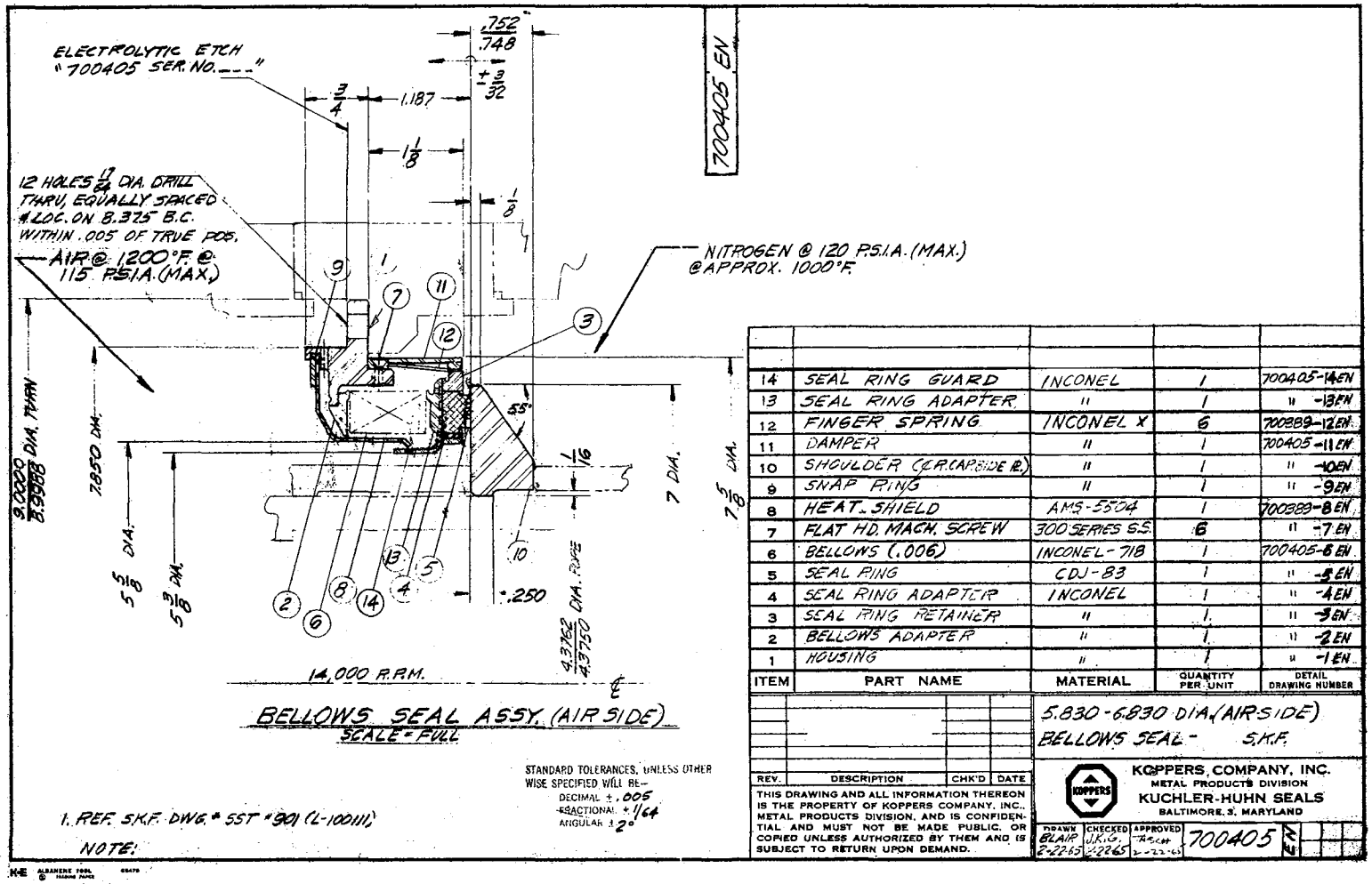


RESEARCH LABORATORY SKF INDUSTRIES, INC.

ENCLOSURE 11

TYPICAL BELLOWS AIR SEAL AND SHOULDER DESIGN

AL68T074



ITEM	PART NAME	MATERIAL	QUANTITY PER UNIT	DETAIL DRAWING NUMBER
14	SEAL RING GUARD	INCONEL	1	700405-14EN
13	SEAL RING ADAPTER	"	1	" -13EN
12	FINGER SPRING	INCONEL X	6	700389-12EN
11	DAMPER	"	1	700405-11EN
10	SHOULDER (CER. CARBIDE R.)	"	1	" -10EN
9	SNAP RING	"	1	" -9EN
8	HEAT SHIELD	AMS-5504	1	700389-8EN
7	FLAT HD. MACH. SCREW	300 SERIES S.S.	6	" -7EN
6	BELLOWS (.006)	INCONEL-718	1	700405-6EN
5	SEAL RING	CDJ-83	1	" -5EN
4	SEAL RING ADAPTER	INCONEL	1	" -4EN
3	SEAL RING RETAINER	"	1	" -3EN
2	BELLOWS ADAPTER	"	1	" -2EN
1	HOUSING	"	1	" -1EN

REV.	DESCRIPTION	CHK'D	DATE

THIS DRAWING AND ALL INFORMATION THEREON IS THE PROPERTY OF KOPPERS COMPANY, INC., METAL PRODUCTS DIVISION, AND IS CONFIDENTIAL AND MUST NOT BE MADE PUBLIC, OR COPIED UNLESS AUTHORIZED BY THEM AND IS SUBJECT TO RETURN UPON DEMAND.

5.830-6.830 DIA. (AIR SIDE)
BELLOWS SEAL - S.K.F.

KOPPERS COMPANY, INC.
METAL PRODUCTS DIVISION
KUCHLER-HUHN SEALS
BALTIMORE 3, MARYLAND

DRAWN	CHECKED	APPROVED
BLAIR 2-22-65	J.K.S. 2-22-65	[illegible] 2-22-65

700405

	Oil Flow Rate, gpm	Time at Test Conditions Hours	Oil Inlet Temp. °F	Test Bearing Temp. °F O.R.	I.R.	Total Seal Leakage Rate, scfm	Conditions at End of Test Period OIL	Test Brg.	Test Seals	Reason for Test *Termination*	Test Conclusion *& Recommendation*
Mobil XRM-109F and Kendex 0839	1	10	490-500	640-645	650-665	2	Viscosity & acid no. up slightly	Slight glazing	Oil Seal shoulder grooved .002-.003	Oil seal lift-off Oil seal shoulder grooved	Suitable for further long term testing
	1.25	10	490-500	640-650	655-690	2.5-2.8					
	1.25	10	500-515	650-660	670-680	1.7-2.5					
	1.25	2.3	500	655	655	9					
Mobil Jet II*	2	1	405	520	505	9.3-10.2	Viscosity & acid no. up slightly	Slight surface distress & heavy cage pocket wear	All sealing elements in good condition	Time-up	*Conditions considered* too severe for long term operations in this system.
	2	9.6	390-435	518-545	500-545	3.8-5.9					
	2	10	390-420	500	500	4.7-6.8					
	2	7.6	390-410	510-525	500-525	4.9-6.6					
	2	2.4	390-405	500-520	485-520	4.5-5.8					
	2	10	400-420	510-530	500-525	5.1-6.8					
	2	10	385-405	500-515	495-520	4.9-6.4					
Mobil XRM-109F,	2	10	500-530	630-650	630-650	9.3-11.7	Viscosity increased	Good	Oil seal & shoulder good. Air seal .005" wear and signs of *chattering* on the air shoulder.	Time-up	Suitable for further long term testing.
	2	10	520-530	630-650	640-650	8.9-10.6					
Mobil XRM-127B &	2	10	515-530	640-660	640-650	10.6-13.6					
	2	6	520	645-650	645-650	10.0-11.9					
Kendex 0839	1.75	10	500-525	650-660	635-660	23.0-30.0					
	1.75	4	505	650	650	19.2-22.5					

* Open Atmosphere

SUMMARY OF TEST OIL VISCOSITY AND ACID NO. DATA

Oil	NEW DEGASSED Visc. @ 100°F Cs/ Acid No.	USED Visc. @ 100°F Cs/ Acid No.	Condition
Mobil 109F + 10% by weight Kendex 0839	550/0.05	648/0.16	20 hrs. @ 630-650°F
		609/0.16[1]	30 hrs. @ 630-660°F
Mobil Jet II	28/0.1	32/0.2	10 hrs. @ 510-545°F
		31/0.2	20 hrs. @ 470-500°F
		31/0.1	30 hrs. @ 500-515°F
		33/0.3	40 hrs. @ 510-530°F
		33/0.3	50 hrs. @ 500-530°F
Mobil 109F, Mobil 127B + 10% by weight Kendex 0839	465/0.1	685/0.1	10 hrs. @ 630-660°F
		742/0.1	20 hrs. @ 630-650°F
		776/0.1	30 hrs. @ 640-660°F
		675/0.1[2]	35.9 hrs. @ 640-650°F
		829/0.1	45.9 hrs. @ 640-660°F
		872/0.1	50 hrs. @ 650°F

1. 1 1/2 gals. of oil were added at the end of 20 hrs.
2. 2 1/2 gals. of oil were added at the end of 30 hrs.

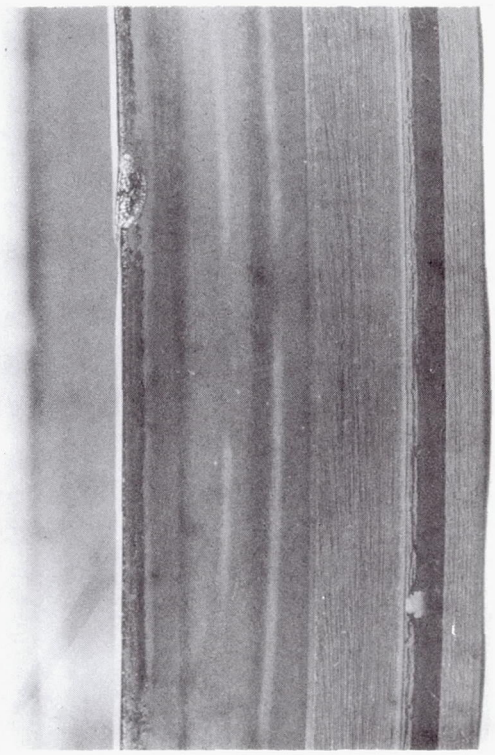
TABULATION OF TEST ELEMENTS USED IN TASK III TESTS

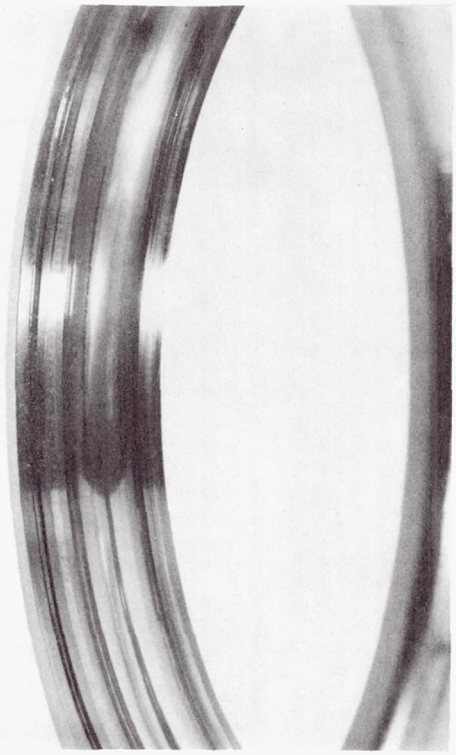
TEST NO.	LUBRICANT	BEARING USED(1)	CAGE(2)	CARBON MAT'L.	DESIGN (3)	PLATING MAT'L	DESIGN (4)	CARBON MAT'L.	DESIGN(5)	PLATING MAT'L	DESIGN (6)
7	Mobil XRM-109F + 10% by weight of Kendex 0839	267107	#10	CDJ83	700489 SN/10	Chrome Carbide	700488-10 SN/1	CDJ83	700405 SN/1	Chrome Carbide	700405-10 SN/1
								56 HT	700397 SN/7		
9	Mobil Jet II	267109	#17	CDJ83	101056B SN/1	Tungsten Carbide	101056 SN/1	56 HT	700397 SN/2	Chrome Carbide	700405-10 SN/1
10	Mobil XRM-109F, Mobil 127B + 10% by weight of Kendex 0839	267110	#6	CDJ83	101056B SN/1	Tungsten Carbide	101056 SN/1	56 HT	700397 SN/2	Chrome Carbide	700405-10 SN/1

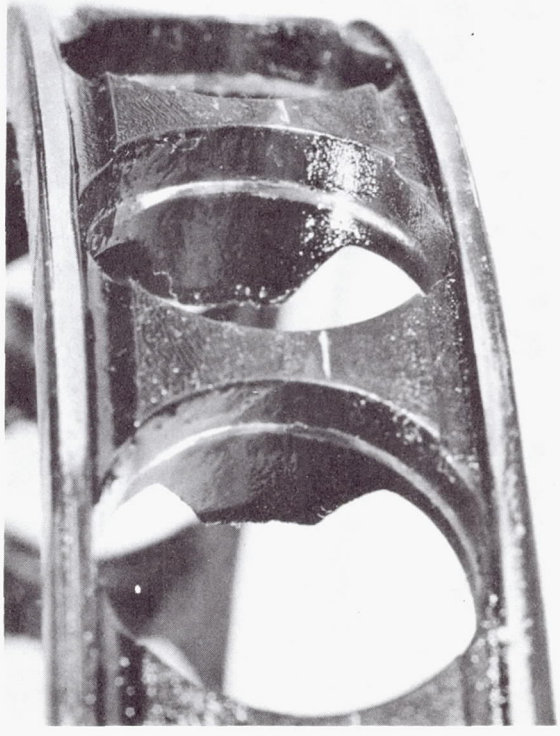
1) All bearings were WB49 steel (459980H) except the one in test 9 which was M-50 steel (459981G).
2) All cages were ion silver plated and were made of 4340 steel.
3) Oil seal bellows were AM350 in test No. 7. Tests #9 and #10 piston type oil seal was used.
4) The oil seal runner in test #9 and #10 were of a new hydrodynamic lift design.
5) The air seal bellows in Test #7 for the first 31.3 hours was an Inco 718. It was replaced by an AM350 steel bellows for remainder of test. Air seal bellows in test #9 and #10 were of AM350.
6) The air seal runners used in these tests were Inco 718

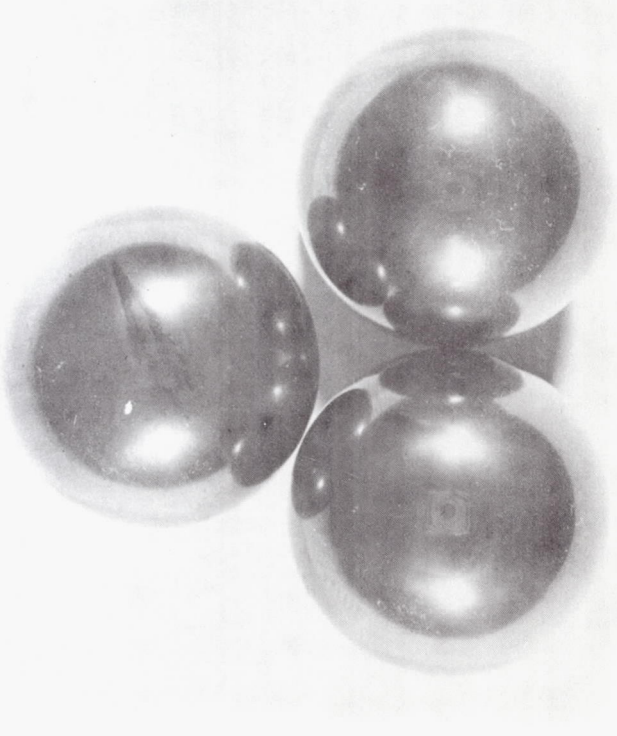
ENCLOSURE 15

INNER RACE, OUTER RACE, CAGE AND BALLS
AFTER 650°F MOBIL XRM-109F
AND 10% BY WEIGHT KENDEX 0839 QUALIFICATION TEST





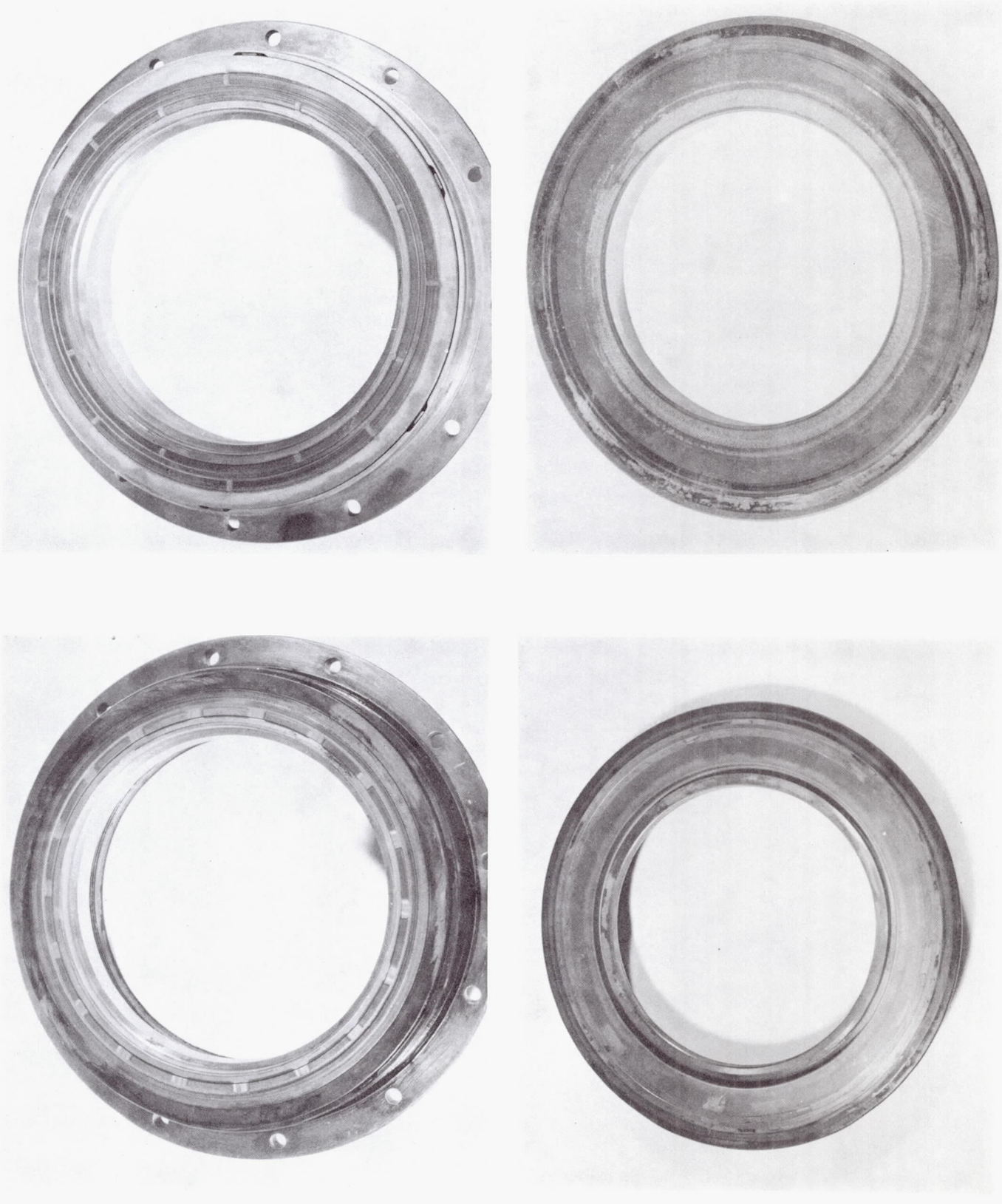




RESEARCH LABORATORY SKF INDUSTRIES, INC.

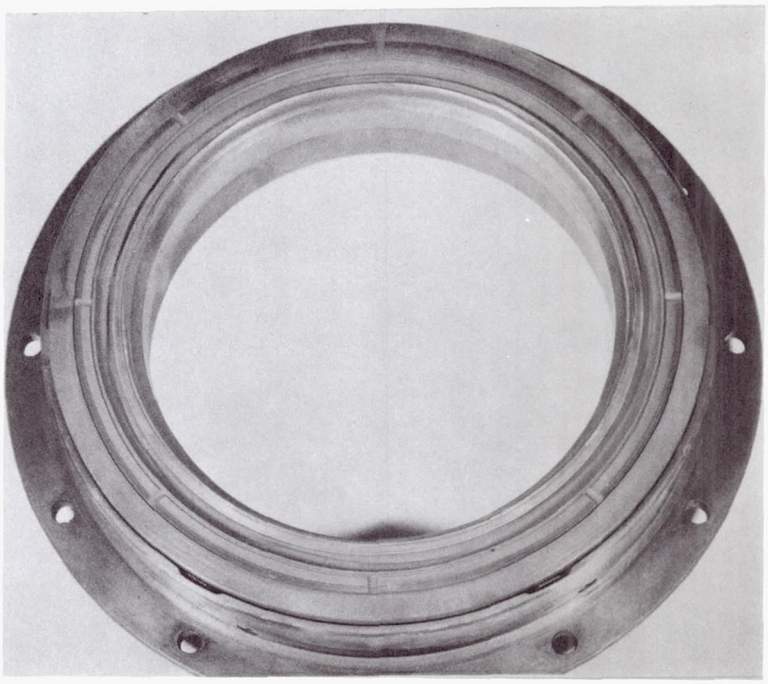
ENCLOSURE 16

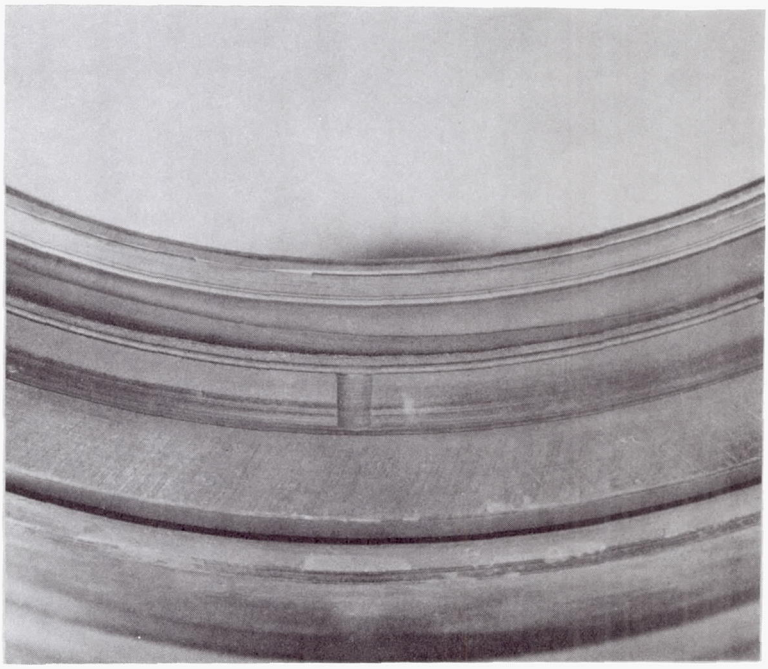
AIR SEAL, AIR SEAL RUNNER, OIL SEAL, AND OIL SEAL RUNNER
AFTER 650°F MOBIL XRM-109F AND
10% BY WEIGHT OF KENDEX 0839 QUALIFICATION TEST



ENCLOSURE 17

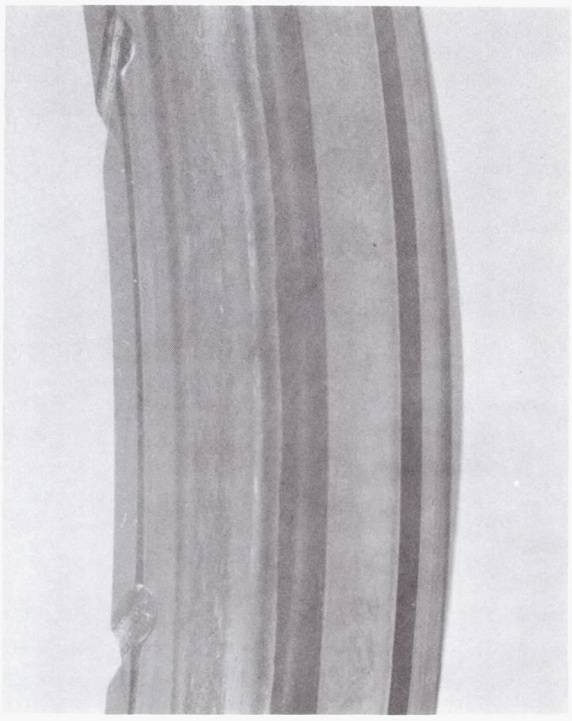
ERODED AIR SEAL AFTER 650°F MOBIL XRM-109F
AND 10% BY WEIGHT OF KENDEX 0839 QUALIFICATION TEST

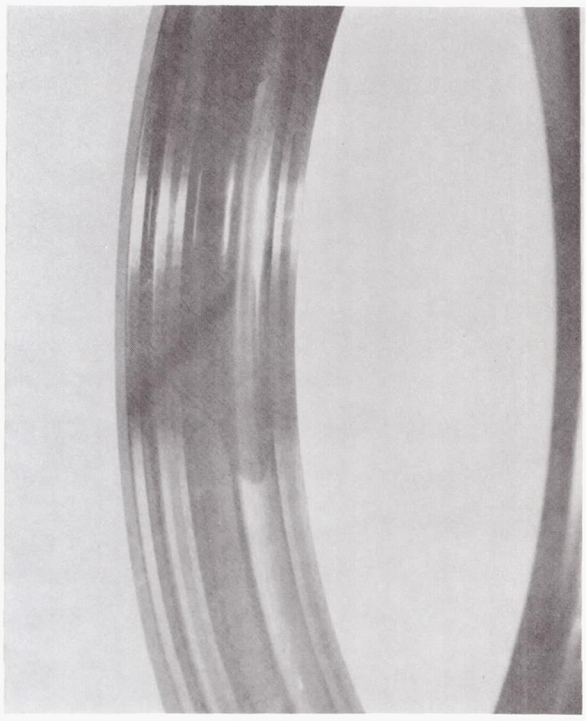


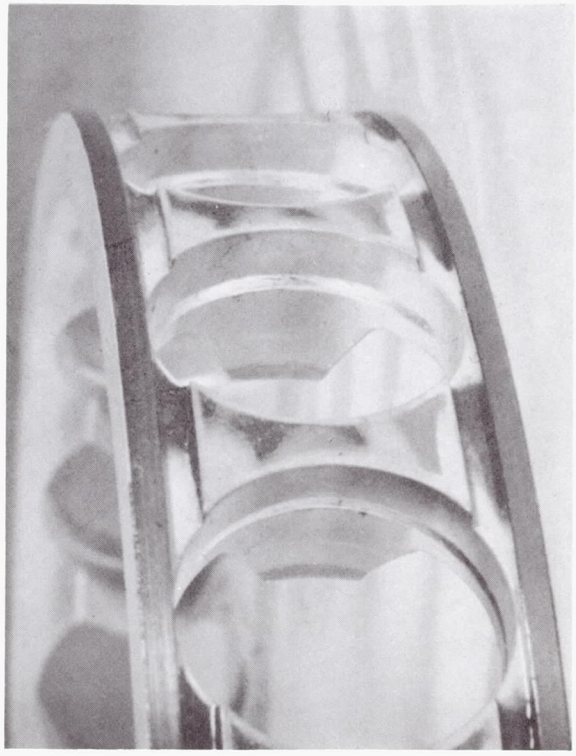


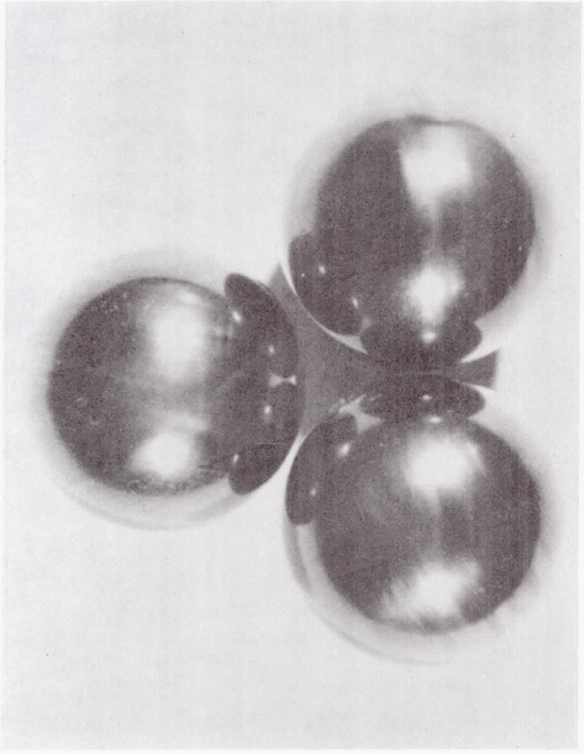
ENCLOSURE 18

INNER RACE, OUTER RACE, CAGE AND BALLS AFTER
500°F MOBIL JET II OPEN ATMOSPHERE BASELINE TEST



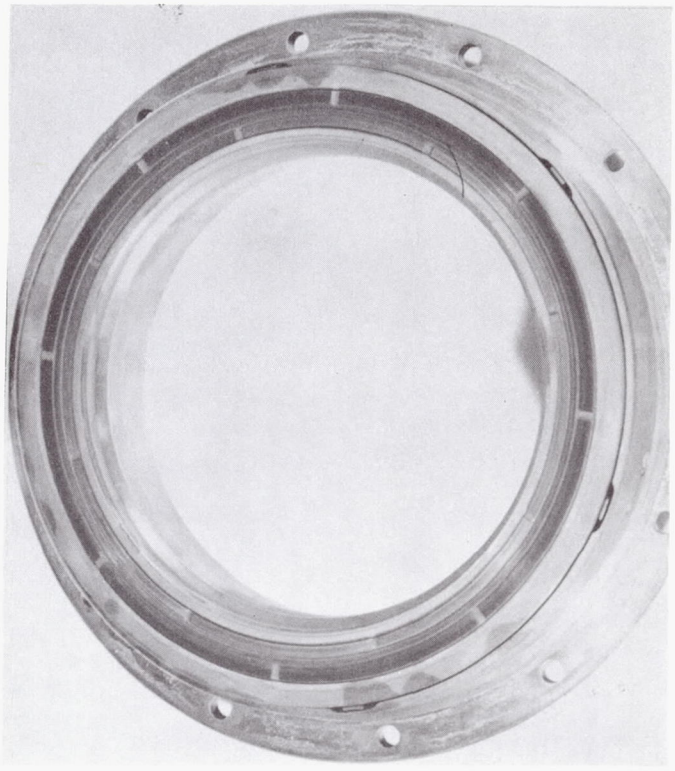


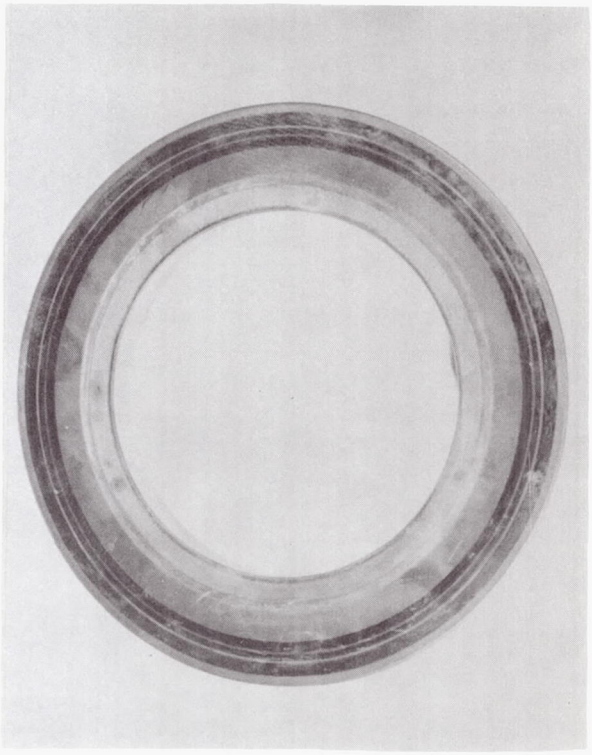


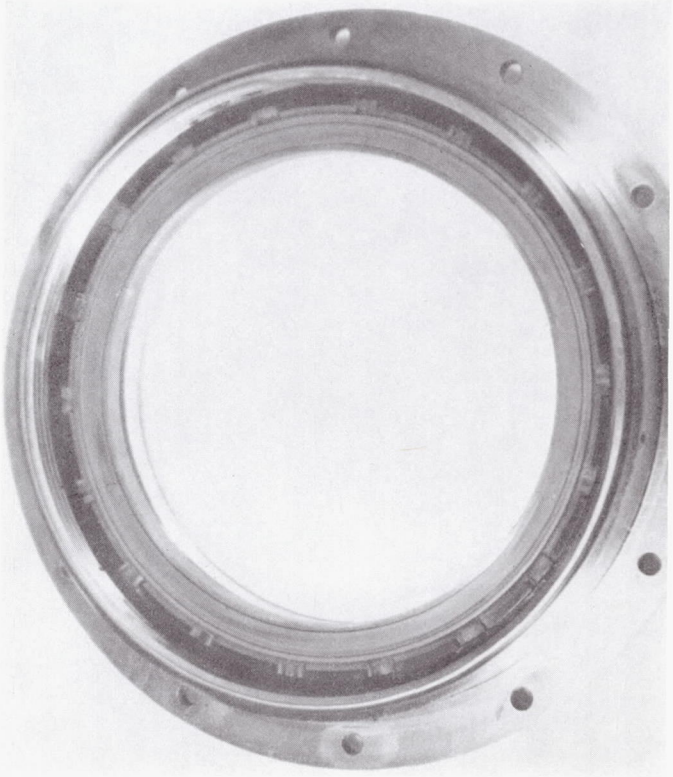


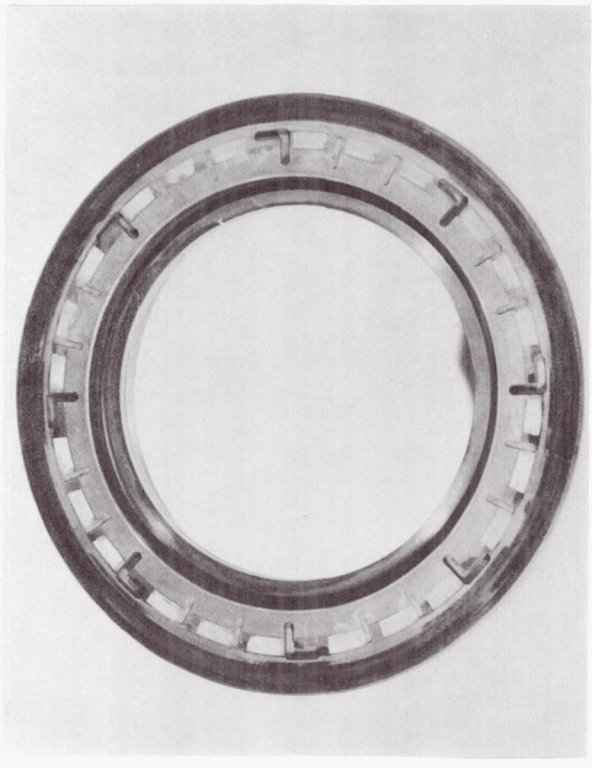
ENCLOSURE 19

AIR SEAL, AIR SEAL RUNNER, OIL SEAL AND OIL SEAL RUNNER
AFTER 500°F MOBIL JET II OPEN ATMOSPHERE BASELINE TEST



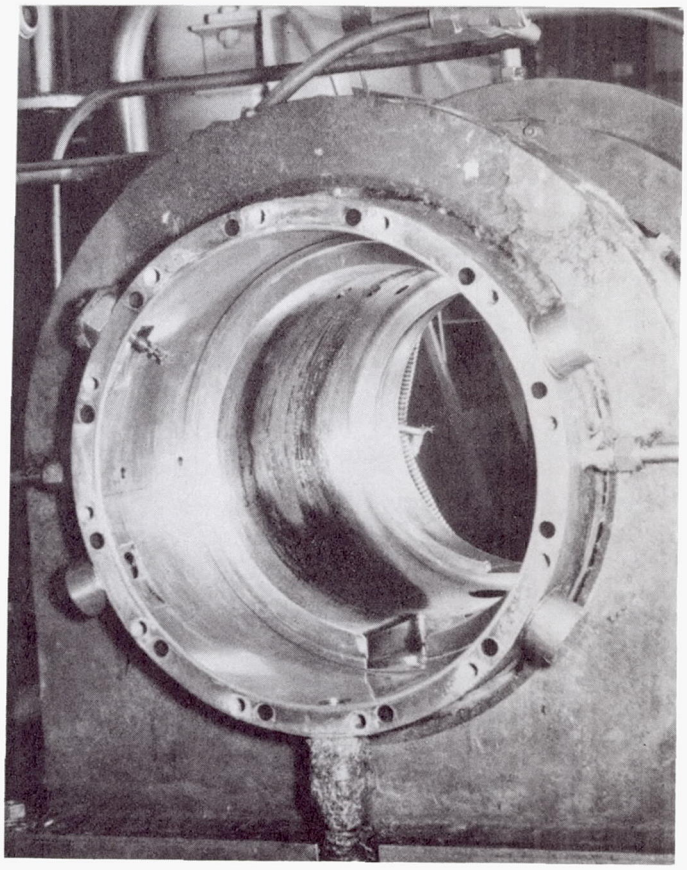


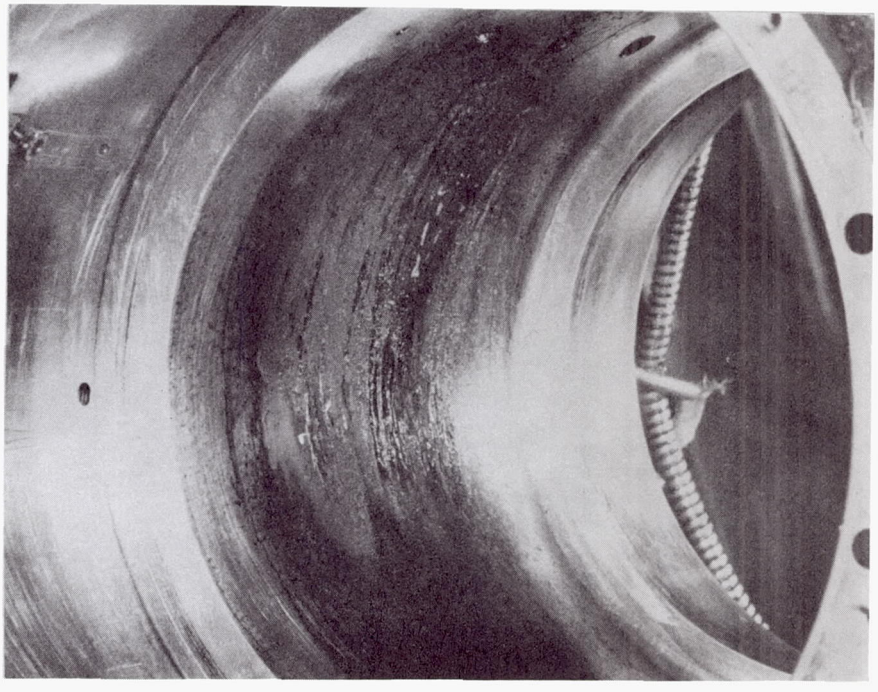




ENCLOSURE 20

BEARING HOUSING BORE AFTER 500°F
MOBIL JET II OPEN ATMOSPHERE BASELINE TEST

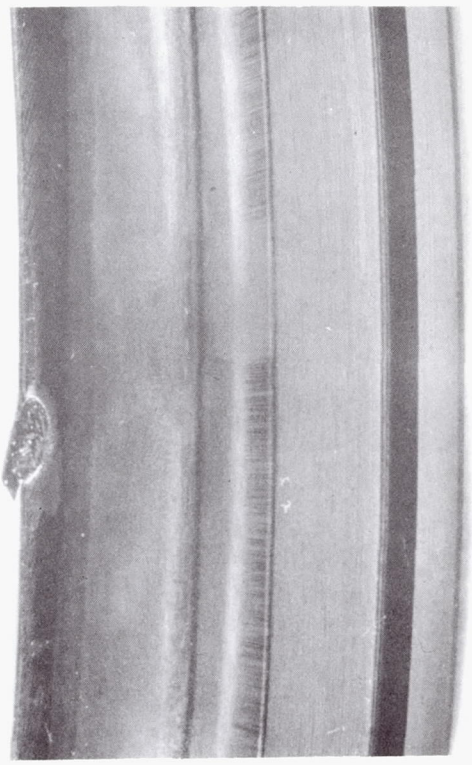


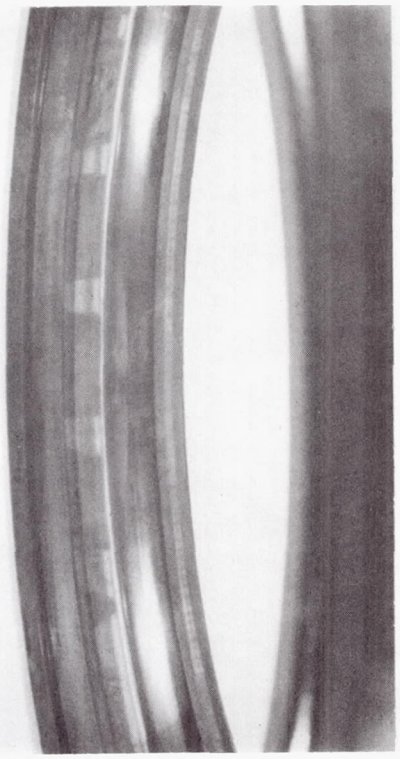


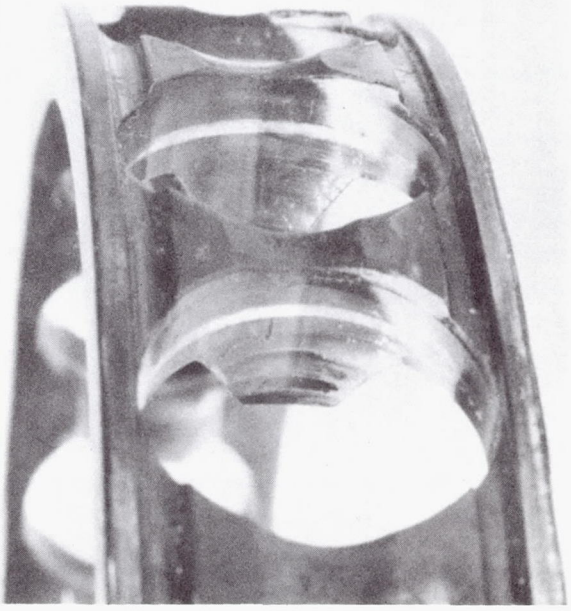
AL68T074

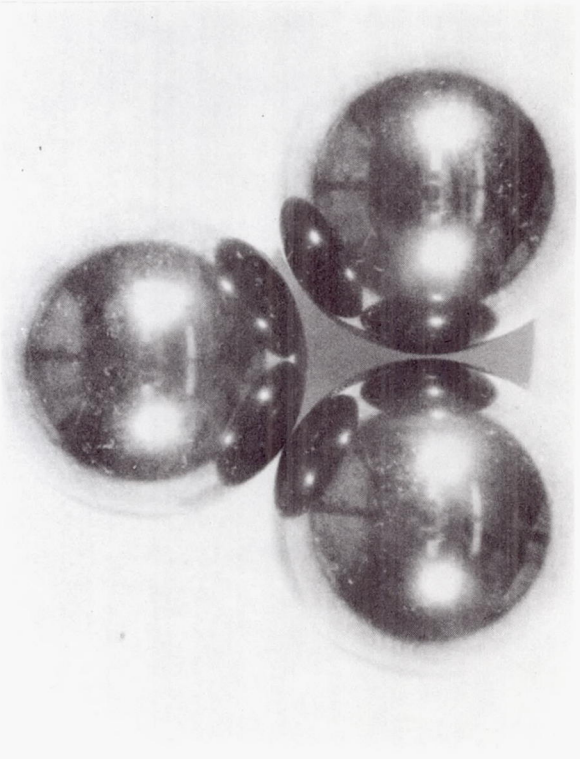
ENCLOSURE 21

INNER RACE, OUTER RACE, CAGE AND BALLS AFTER 650°F MOBIL XRM-109F, MOBIL XRM-127B AND 10% BY WEIGHT KENDEX 0839 QUALIFICATION TEST





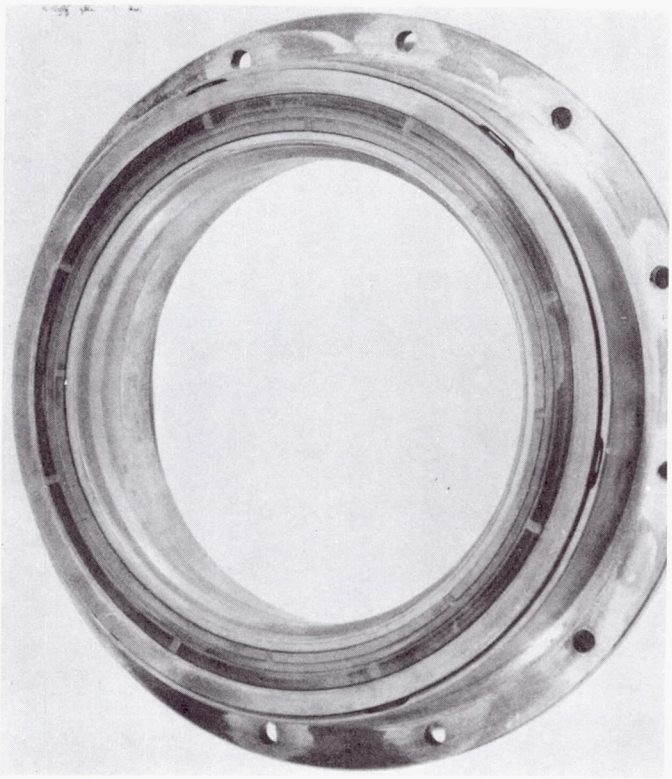


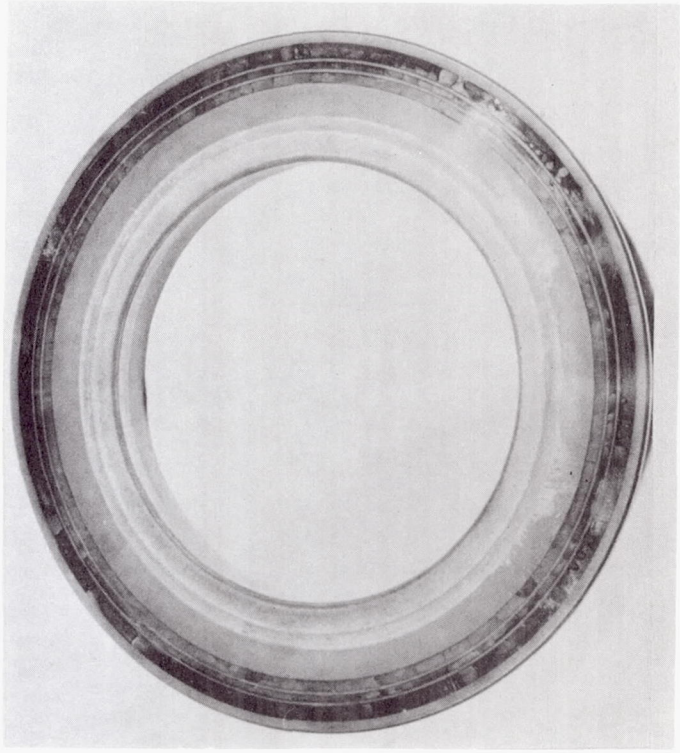


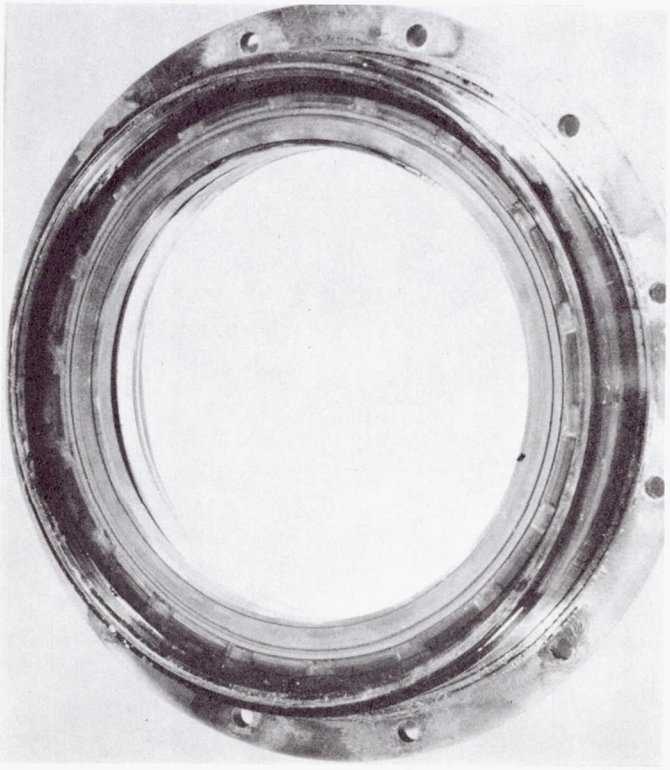
RESEARCH LABORATORY SKF INDUSTRIES, INC.

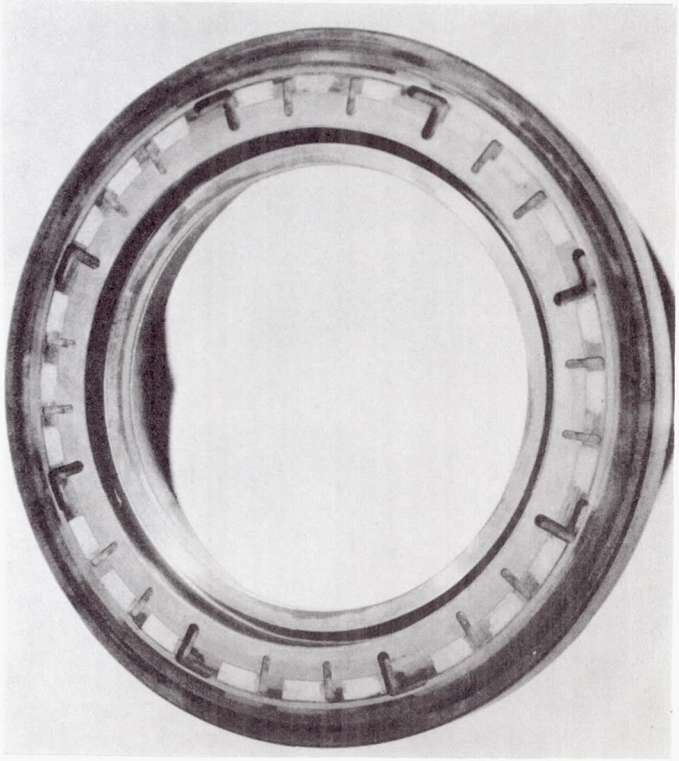
ENCLOSURE 22

AIR SEAL, AIR SEAL RUNNER, OIL SEAL, OIL SEAL RUNNER AFTER 650°F MOBIL XRM-109F, MOBIL XRM-127B AND 10% BY WEIGHT KENDEX 0839 QUALIFICATION TEST



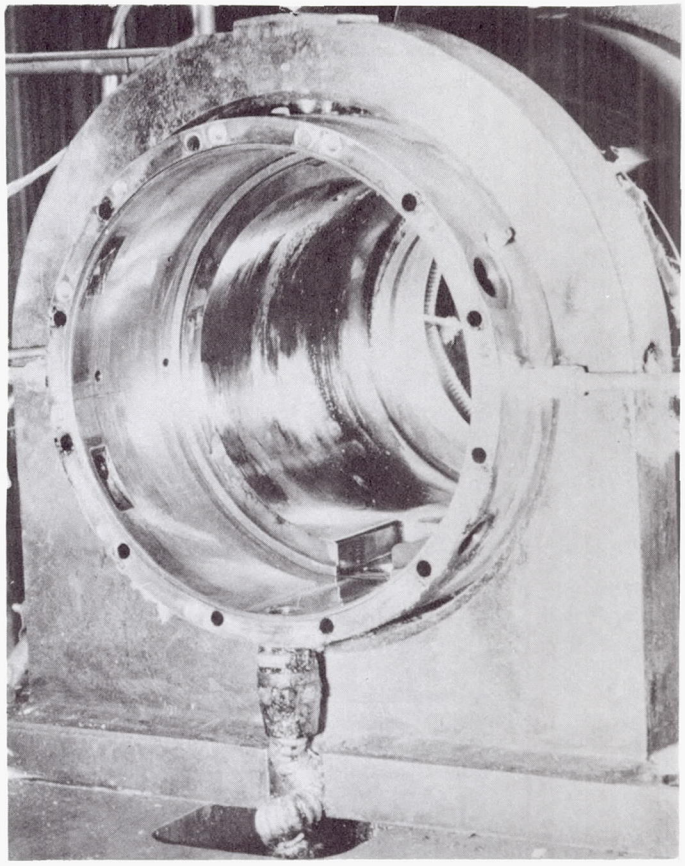


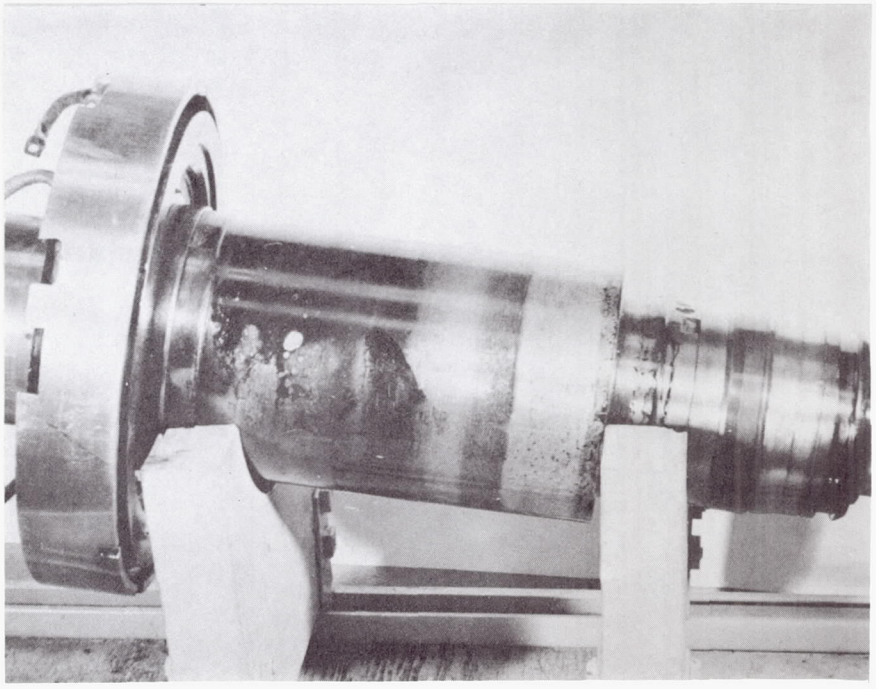




ENCLOSURE 23

BEARING HOUSING BORE AND TEST SHAFT
AFTER 650°F MOBIL XRM-109F, MOBIL XRM-127B
AND 10% BY WEIGHT KENDEX 0839 QUALIFICATION TEST





APPENDIX I

SUMMARY DATA SHEETS FOR 50-HOUR TASK III TESTS

TEST BEARING # 267107

OIL USED MOBIL XRM 108F + 10 o/o by WGT. KENDEX 0839 DATE 3-7-68

RUNNING TIME, HOURS	2.6	2.8	3.2	3.7	4.2	5.0	5.8	6.6	7.6	8.6	9.6	10.6
SPEED, RPM		14			14	14	14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)		106			106	106	106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)		6			6	6	6	6	6-7	6-7	6-7	6-7
SEAL CAVITY PRESS. (PSI)		111			111	111	111	111	111	111	111	111
HOT AIR FLOW (SCFM)		30			33	36	36	36	36	36	36	36
TEST OIL FLOW (GPM)		1			1	1	1	1	1	1	1	1
TOTAL SEAL LEAKAGE (SCFM)		—			2.8	2.0	—	2	2	2	2	2
TEST BEARING OUTER RING (°F)		640			640	640	640	640	640	640	645	645
TEST BEARING INNER RING (°F)		665			660	660	660	650	660	660	665	665
ROLLER BEARING OUTER RING (°F)		560			625	605	600	560	500	485	495	490
OIL SEAL HOUSING (°F)		825			845	865	840	740	780	780	780	780
AIR SEAL HOUSING (°F)		955			865	890	850	740	925	950	960	950
TEST BEARING HOUSING (°F)		720			610	630	560	420	480	480	480	480
ROLLER BEARING HOUSING (°F)		705			610	630	570	500	490	480	480	480
AIR SEAL BELLOWS (°F)		935			840	890	830	730	910	930	93	920
HOT AIR IN MANIFOLD (°F)		—			—	—	—	—	—	—	—	—
OIL INLET (°F)		500			500	510	500	470	500	490	500	500
OIL OUTLET (°F)		505			540	535	520	570	470	460	470	470

TEST CONDITIONS

STOP RESTART

TEST CONDITIONS

MALFUNCTION OF I.R. HIGH TEMPERATURE SHUT DOWN

During the first test period the majority of the total seal leakage was across the oil seal.

The oxygen content in the test bearing chamber was 0.014-0.02%.

TEST BEARING # 267107

OIL USED MOBILXRM109F + 10 o/o BY WGT. KENDEX 0839 DATE 3/7-8/68

RUNNING TIME, HOURS	11.4	12.9	13.1	14.5	14.6	15.4	16.4	17.4	18.9	20.7	21.7	22.7
SPEED, RPM	14	14			14	14	14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106	106			106	106	106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)	6-7	6-7			6-8	6-8	6-8	6-8	6-8	6-8	6-8	6-8
SEAL CAVITY PRESS. (PSI)	111	111			111	111	111	111	111	111	111	111
HOT AIR FLOW (SCFM)	36	36			24	24	24	44	44	40	40	40
TEST OIL FLOW (GPH)	1	1			1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
TOTAL SEAL LEAKAGE (SCFH)	2	2			2.8	2.8	2.7	2.5	2.7	2.5	2.6	2.5
TEST BEARING OUTER RING (°F)	640	640			650	650	650	655	650	640	630	650
TEST BEARING INNER RING (°F)	660	660			660	690	655	690	675	670	670	675
ROLLER BEARING OUTER RING (°F)	490	490			525	520	500	528	525	525	520	510
OIL SEAL HOUSING (°F)	780	770			690	715	715	760	760	770	760	770
AIR SEAL HOUSING (°F)	945	940			820	870	860	945	950	950	945	950
TEST BEARING HOUSING (°F)	480	480			480	480	480	480	480	490	480	490
ROLLER BEARING HOUSING (°F)	480	480			475	475	480	480	510	510	500	510
AIR SEAL BELLOWS (°F)	930	920			820	860	855	920	925	920	900	910
HOT AIR IN MANIFOLD (°F)	—	—			—	—	—	—	—	—	—	—
OIL INLET (°F)	500	500			500	490	490	490	490	500	490	500
OIL OUTLET (°F)	470	470			470	465	470	470	470	480	470	475

STOP .. RESTART

TEST CONDITIONS

↳ END OF FIRST TEST PERIOD

During the 2nd 10-hour test period the majority of the total seal leakage for the first 5 hours was across the oil seal and approximately equal between the oil and the air seal for the last 5 hours.

The oxygen content in the test bearing chamber was 0.015-0.054%.

TEST BEARING # 267107

OIL USED MOBIL XRM109A 10 o/o BY WGT. KENDEX 0839 DATE 3/8-12/68

RUNNING TIME, HOURS	24.2	24.5	25.2	25.5	26.2	27.2	28.2	28.7	29.2	30.2	31.2	32.2
SPEED, RPM	14			14	14	14	14		14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106			106	106	106	106		106	106	106	106
BEARING CAVITY PRESS. (PSI)	6-8			6	6	6	6		6	6	6	6
SEAL CAVITY PRESS. (PSI)	111			111	111	111	111		111	111	111	111
HOT AIR FLOW (SCFM)	40			50	45	48	48		48	48	48	48
TEST OIL FLOW (GPH)	1.25			1.25	1.25	1.25	1.25		1.25	1.25	1.25	1.25
TOTAL SEAL LEAKAGE (SCFM)	2.5			2.4	2.5	2	2		2	1.7	1.8	1.8
TEST BEARING OUTER RING (°F)	640			650	650	650	650		650	650	655	660
TEST BEARING INNER RING (°F)	660			680	680	672	680		670	670	670	680
ROLLER BEARING OUTER RING (°F)	480			565	560	585	605		585	610	620	620
OIL SEAL HOUSING (°F)	755			830	840	830	835		820	825	825	820
AIR SEAL HOUSING (°F)	940			1000	1000	1005	1010		1005	1005	1010	1010
TEST BEARING HOUSING (°F)	480			675	690	670	675		665	670	670	645
ROLLER BEARING HOUSING (°F)	500			615	640	640	645		650	650	650	640
AIR SEAL BELLOWS (°F)	910			980	990	985	990		980	980	985	985
HOT AIR IN MANIFOLD (°F)	—			—	—	—	—		—	—	—	—
OIL INLET (°F)	500			515	500	500	500		500	500	500	500
OIL OUTLET (°F)	465			500	490	490	495		495	495	500	490

STOP. RESTART TEST CONDITIONS.

MOMENTARY INCREASE IN TOTAL SEAL LEAKAGE

↳ END OF SECOND TEST PERIOD

During the third 10-hour test period the majority of the total seal leakage was across the oil seal.

The oxygen content in the test bearing chamber was 0.01%.

TEST BEARING # 267107

OIL USED MOBIL XRM109F+10 o/o BY WGT. KENDEX 0839 DATE 3/12-26/68

RUNNING TIME, HOURS	33.2	34.2	34.9	35.2	38.1	39.1	39.9	41.2				
SPEED, RPM	14	14	14				14					
AIR MANIFOLD PRESS. (PSI)	106	106	106				106					
BEARING CAVITY PRESS. (PSI)	6	6	6				6					
SEAL CAVITY PRESS. (PSI)	111	111	111				111					
HOT AIR FLOW (SCFM)	49	50	50				55					
TEST OIL FLOW (GPM)	1.25	1.25	1.25				1.25					
TOTAL SEAL LEAKAGE (SCFM)	1.8.	1.8	1.9				9					
TEST BEARING OUTER RING (°F)	650	650	650				655					
TEST BEARING INNER RING (°F)	670	670	670				655					
ROLLER BEARING OUTER RING (°F)	550	550	550				530					
OIL SEAL HOUSING (°F)	820	820	810				685					
AIR SEAL HOUSING (°F)	1010	1005	990				935					
TEST BEARING HOUSING (°F)	640	650	650				595					
ROLLER BEARING HOUSING (°F)	640	640	640				580					
AIR SEAL BELLOWS (°F)	980	980	980				820					
HOT AIR IN MANIFOLD (°F)	—	—	—				—					
OIL INLET (°F)	500	500	500				500					
OIL OUTLET (°F)	480	480	480				475					

STOP RESTART TEST CONDITIONS STOP RESART TEST TERMINATED

→ OIL SEAL LIFT OFF

→ TEST CONDITIONS

→ I HSG. HEATERS AND AIR SEAL REPLACED

→ END OF THIRD TEST PERIOD

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE) DATE 5/20-22/68

RUNNING TIME, HOURS	0.8	1.2	1.9	2.7	3.4	4.2	5.2	6.2	7.2	8.2	9.2	10.2
SPEED, RPM	14			14		14	14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106			106		106	106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)	6			6		6	6	6	6	6	6	6
SEAL CAVITY PRESS. (PSI)	111			111		111	111	111	111	111	111	111
HOT AIR FLOW (SCFM)	50			40		42	53	54	49	49	49	52
TEST OIL FLOW (GPM)	2			2		2	2	2	2	2	2	2
TOTAL SEAL LEAKAGE (SCFM)	10.2			9.3		4.6	4.8	5.3	4.2	5.9	4.2	3.8
TEST BEARING OUTER RING (°F)	520			520		518	530	545	535	525	520	510
TEST BEARING INNER RING (°F)	500			505		500	525	545	525	515	510	500
ROLLER BEARING OUTER RING (°F)	430			435		425	445	455	425	410	405	400
OIL SEAL HOUSING (°F)	—			—		—	—	—	—	—	—	—
AIR SEAL HOUSING (°F)	840			810		800	865	890	860	845	850	870
TEST BEARING HOUSING (°F)	500			525		500	495	490	400	390	370	380
ROLLER BEARING HOUSING (°F)	465			510		500	490	480	410	390	390	360
AIR SEAL BELLOWS (°F)	—			—		—	—	—	—	—	—	—
HOT AIR IN MANIFOLD (°F)	1200			1160		1060	1130	1160	1150	1150	1160	1180
OIL INLET (°F)	410			400		400	420	435	420	410	400	390
OIL OUTLET (°F)	435			415		410	430	440	415	400	400	390

STOP: RESTART SHEAR PINS

STOP: RESTART OIL LEAK

STOP: RESTART SHEAR PINS

TEST CONDITIONS

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE) DATE 5/22-24/68

RUNNING TIME, HOURS	11.2	12.2	13.2	13.8	14.6	15.6	16.8	17.6	18.6	19.6	20.8	21.7
SPEED, RPM	14	14	14		14	14	14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106	106	106		106	106	106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)	6	6	6		6	6	6	6	6	6	6	6
SEAL CAVITY PRESS. (PSI)	111	111	111		111	111	111	111	111	111	111	111
HOT AIR FLOW (SCFM)	52	52	52	RESTART	35	48	48	46	55	52	52	52
TEST OIL FLOW (GPM)	2	2	2		2	2	2	2	2	2	2	2
TOTAL SEAL LEAKAGE (SCFM)	4.6	5.9	5.5		4.9	—	5.0	4.7	5.0	5.0	4.9	6.6
TEST BEARING OUTER RING (°F)	510	520	520		500	520	470	500	500	500	500	500
TEST BEARING INNER RING (°F)	510	510	510		490	520	480	500	500	500	500	500
ROLLER BEARING OUTER RING (°F)	400	400	410		420	470	390	420	420	420	420	420
OIL SEAL HOUSING (°F)	—	—	—		—	—	—	—	—	—	—	—
AIR SEAL HOUSING (°F)	860	860	870		780	825	860	855	855	855	855	870
TEST BEARING HOUSING (°F)	380	380	380		495	495	485	490	490	490	500	505
ROLLER BEARING HOUSING (°F)	360	360	350		495	495	485	490	490	490	490	490
AIR SEAL BELLOWS (°F)	—	—	—		—	—	—	—	—	—	—	—
HOT AIR IN MANIFOLD (°F)	1180	1180	1190		1020	1080	1090	1100	1120	1120	1120	1150
OIL INLET (°F)	390	390	390		490	420	390	390	390	390	390	390
OIL OUTLET (°F)	390	390	400		400	430	380	400	405	405	410	400

STOP — NO GO

TEST CONDITIONS

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE)

DATE 5/24-27/68

RUNNING TIME, HOURS	22.6	23.7	24.4	24.6	25.3	26.3	27.3	28.3	29.3	30.3	31.3	32.4
SPEED, RPM	14	14	14		14	14	14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106	106	106		106	106	106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)	6	6	6		6	6	6	6	6	6	6	6
SEAL CAVITY PRESS. (PSI)	111	111	111		111	111	111	111	111	111	111	111
HOT AIR FLOW (SCFM)	52	52	52	START	50	—	48	46	46	46	46	46
TEST OIL FLOW (GPM)	2	2	2		2	2	2	2	2	2	2	2
TOTAL SEAL LEAKAGE (SCFM)	6.8	5.6	6.6		—	4.9	5.7	5.5	6.6	5.8	5.7	5.1
TEST BEARING OUTER RING (°F)	500	500	500		510	525	520	520	520	525	515	515
TEST BEARING INNER RING (°F)	500	500	500		500	525	520	520	520	525	515	515
ROLLER BEARING OUTER RING (°F)	420	420	420		430	450	440	440	450	450	430	420
OIL SEAL HOUSING (°F)	—	—	—		—	—	—	—	—	—	—	—
AIR SEAL HOUSING (°F)	870	870	870		785	850	870	880	880	920	920	920
TEST BEARING HOUSING (°F)	500	500	500		500	495	495	495	490	490	—	—
ROLLER BEARING HOUSING (°F)	490	490	500		490	490	495	495	490	490	—	—
AIR SEAL BELLOWS (°F)	—	—	—		—	—	—	—	—	—	—	—
HOT AIR IN MANIFOLD (°F)	1150	1150	1150		1150	1110	1130	1130	1140	1200	1170	1200
OIL INLET (°F)	390	390	390		390	420	410	410	410	410	410	410
OIL OUTLET (°F)	400	400	390		—	—	—	—	—	—	—	—

START TEST PERIOD

STOP: END OF TEST PERIOD

TEST CONDITIONS

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE) DATE 5/27-28/68

RUNNING TIME, HOURS	32.9	33.3	33.9	34.9	35.3	35.4	35.7	36.7	37.7	38.7	39.7	40.7
SPEED, RPM		14	14	14	14		14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)		106	106	106	106		106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)		6	6	6	6		6	6	6	6	6	6
SEAL CAVITY PRESS. (PSI)		111	111	111	111		111	111	111	111	111	111
HOT AIR FLOW (SCFM)		54	50	50	49		45	50	50	48	48	48
TEST OIL FLOW (GPM)		2	2	2	2		2	2	2	2	2	2
TOTAL SEAL LEAKAGE (SCFM)		4.5	5.8	5.3	5.1		5.5	5.5	—	6.5	6.8	6.3
TEST BEARING OUTER RING (°F)		500	512	502	520		515	510	520	525	530	525
TEST BEARING INNER RING (°F)		485	505	500	520		500	510	520	525	525	525
ROLLER BEARING OUTER RING (°F)		410	420	400	420		440	420	435	440	445	440
OIL SEAL HOUSING (°F)		—	—	—	—		—	—	—	—	—	—
AIR SEAL HOUSING (°F)		740	880	880	880		760	860	860	865	865	860
TEST BEARING HOUSING (°F)		380	370	390	390		415	420	470	480	485	485
ROLLER BEARING HOUSING (°F)		380	390	405	405		415	410	465	475	475	465
AIR SEAL BELLOWS (°F)		—	—	—	—		—	—	—	—	—	—
HOT AIR IN MANIFOLD (°F)		1000	1150	1170	1145		1030	1110	1110	1110	1110	1115
OIL INLET (°F)		390	395	395	405		415	400	410	410	415	410
OIL OUTLET (°F)		—	—	—	—		—	—	—	—	—	—

STOP: RESTART PINS SHEAR

STOP: RESTART PERIOD OF END TEST

TEST CONDITIONS

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE) DATE 5/28-29/68

RUNNING TIME, HOURS	41.8	42.8	43.8	44.8	45.8	46.6	47.4	47.9	48.3	49.3	50.3	51.3
SPEED, RPM	14	14	14	14		14	14		14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106	106	106	106		106	106		106	106	106	106
BEARING CAVITY PRESS. (PSI)	6	6	6	6		6	6		6	6	6	6
SEAL CAVITY PRESS. (PSI)	111	111	111	111		111	111		111	111	111	111
HOT AIR FLOW (SCFM)	48	48	48	48		46	48		44	48	45	45
TEST OIL FLOW (GPM)	2	2	2	2		2	2		2	2	2	2
TOTAL SEAL LEAKAGE (SCFM)	5.1	5.2	6.2	6.5		6.2	6.9		4.9	5.4	5.1	5.4
TEST BEARING OUTER RING (°F)	520	520	520	525		520	530		515	512	500	500
TEST BEARING INNER RING (°F)	520	520	520	525		500	525		500	520	510	505
ROLLER BEARING OUTER RING (°F)	445	440	440	450		430	450		430	430	440	420
OIL SEAL HOUSING (°F)	—	—	—	—		—	—		—	—	—	—
AIR SEAL HOUSING (°F)	865	865	860	860		855	880		860	870	875	870
TEST BEARING HOUSING (°F)	470	465	475	500		430	490		490	430	485	460
ROLLER BEARING HOUSING (°F)	480	465	470	480		430	480		480	440	475	450
AIR SEAL BELLOWS (°F)	—	—	—	—		—	—		—	—	—	—
HOT AIR IN MANIFOLD (°F)	1110	110	1110	1110		1130	1160		1145	1150	1160	1150
OIL INLET (°F)	415	415	410	420		410	425		400	405	390	380
OIL OUTLET (°F)	—	—	—	—		—	—		—	—	—	—

STOP - END OF TEST PERIOD

RESTART

STOP - COMPRESSOR SHUT DOWN

RESTART

TEST CONDITIONS

AL68T074

TEST BEARING # 267109

OIL USED MOBIL JET II (OPEN ATMOSPHERE) DATE 5/29/68

RUNNING TIME, HOURS	52.3	53.3	54.3	55.3	55.9	56.5							
SPEED, RPM	14	14	14	14	14								
AIR MANIFOLD PRESS. (PSI)	106	106	106	106	106								
BEARING CAVITY PRESS. (PSI)	6	6	6	6	6								
SEAL CAVITY PRESS. (PSI)	111	111	111	111	111								
HOT AIR FLOW (SCFM)	45	45	45	45	45								
TEST OIL FLOW (GPM)	2	2	2	2	2								
TOTAL SEAL LEAKAGE (SCFM)	6.0	6.1	6.0	6.4	5.5								
TEST BEARING OUTER RING (°F)	505	500	500	500	500								
TEST BEARING INNER RING (°F)	510	500	500	495	495								
ROLLER BEARING OUTER RING (°F)	415	410	410	410	410								
OIL SEAL HOUSING (°F)	—	—	—	—	—								
AIR SEAL HOUSING (°F)	880	885	890	885	885								
TEST BEARING HOUSING (°F)	425	415	430	430	430								
ROLLER BEARING HOUSING (°F)	425	415	420	420	420								
AIR SEAL BELLOWS (°F)	—	—	—	—	—								
HOT AIR IN MANIFOLD (°F)	1150	1150	1155	1155	1155								
OIL INLET (°F)	390	385	390	39	390								
OIL OUTLET (°F)	—	—	—	—	—								

STOP: TEST COMPLETED

TEST BEARING # 267110

OIL USED MOBIL XRM 109F, MOBIL XRM 127B + 10 o/o BY W.T. KENDEX 0839 DATE 6/10-13/68

RUNNING TIME, HOURS	3.7	4.8	5.8	6.8	7.8	8.8	9.8	10.8	11.8	12.8	13.8	14.8
SPEED, RPM		14	14	14	14	14	14	14	14	14	14	
AIR MANIFOLD PRESS. (PSI)		106	106	106	106	106	106	106	106	106	106	
BEARING CAVITY PRESS. (PSI)		6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	
SEAL CAVITY PRESS. (PSI)		111	111	111	111	111	111	111	111	111	111	
HOT AIR FLOW (SCFM)		46	46	46	41	43	43	43	43	43	43	
TEST OIL FLOW (GPM)		2	2	2	2	2	2	2	2	2	2	
TOTAL SEAL LEAKAGE (SCFM)		11.3	10.2	10.2	9.7	9.4	11.3	9.3	11.7	10	9.3	
TEST BEARING OUTER RING (°F)		630	640	650	650	650	650	650	650	650	650	
TEST BEARING INNER RING (°F)		630	640	640	650	650	650	650	640	650	650	
ROLLER BEARING OUTER RING (°F)		540	570	570	570	560	570	570	570	560	560	
OIL SEAL HOUSING (°F)		—	—	—	—	—	—	—	—	—	—	
AIR SEAL HOUSING (°F)		1000	980	970	975	980	980	980	980	980	980	
TEST BEARING HOUSING (°F)		670	720	725	735	730	730	720	700	690	690	
ROLLER BEARING HOUSING (°F)		625	680	690	700	700	700	700	690	685	690	
AIR SEAL BELLOWS (°F)		835	800	790	800	800	800	800	800	800	800	
HOT AIR IN MANIFOLD (°F)		1190	1200	1200	1200	1200	1200	1200	1190	1200	1195	
OIL INLET (°F)		500	510	515	530	530	530	530	525	525	530	
OIL OUTLET (°F)		530	520	520	550	555	550	550	550	550	545	

STOP: RESTART HSG HEATERS BLEW

STOP: RESTART END OF TEST PERIOD

↳ TEST CONDITIONS

TEST BEARING # 267110

OIL USED MOBIL XRM 109F, MOBIL XRM127B + 10% BY WGT. KENDEX 0839 DATE 6/14/68

Running Time, Hours	15.6	16.6	17.7	18.7	19.7	20.7	21.7	22.7	23.7	24.7	25.7	26.6
Speed, RPM	14	14	14	14	14	14	14	14	14	14		14
Air Manifold Press. (psi)	106	106	106	106	106	106	106	106	106	106		106
Bearing Cavity Press. (psi)	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7		6-7
Seal Cavity Press. (psi)	111	111	111	111	111	111	111	111	111	111		111
Hot Air Flow (scfm)	40	40	40	40	40	48	48	48	48	48		46
Test Oil Flow (gpm)	2	2	2	2	2	2	2	2	2	2	RESTART	2
Total Seal Leakage (scfm)	10.2	9.2	9.9	9.3	8.9	10.6	10.6	9.5	10.6	10.4		12.2
Test Bearing Outer Ring (°F)	640	650	645	645	630	640	640	640	640	640		640
Test Bearing Inner Ring (°F)	620	640	645	650	640	640	650	650	640	640		630
Roller Bearing Outer Ring (°F)	545	555	565	565	555	560	555	560	560	560		530
Oil Seal Housing (°F)	—	—	—	—	—	—	—	—	—	—		—
Air Seal Housing (°F)	950	970	975	975	875	990	990	995	995	995		965
Test Bearing Housing (°F)	670	715	715	705	700	700	705	705	705	690		620
Roller Bearing Housing (°F)	620	—	—	—	—	—	—	—	—	—	STOP: END OF TEST PERIOD	—
Air Seal Bellows (°F)	770	800	800	800	800	815	820	820	820	820		790
Hot Air in Manifold (°F)	1180	1190	1190	1190	1190	1200	1200	1200	1200	1200		1190
Oil Inlet (°F)	530	530	530	530	530	525	520	520	520	520		515
Oil Outlet (°F)	520	560	550	555	535	545	545	545	545	545		520

TEST CONDITIONS

The majority of the total seal leakage was across the oil seal.

The oxygen content in the test bearing chamber was 0.011%.

TEST BEARING # 267110

OIL USED MOBIL XRM109F, MOBIL XRM127B + 10% BY WGT. KENDEX 0839 DATE 6/14-17/68

Running Time, Hours	27.6	28.6	29.6	30.6	31.6	32.6	33.6	34.6	35.6	36.6	36.7	37.5
Speed, RPM	14	14	14	14	14	14	14	14	14	14		14
Air Manifold Press. (psi)	106	106	106	106	106	106	106	106	106	106		106
Bearing Cavity Press. (psi)	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7		6-7
Seal Cavity Press. (psi)	111	111	111	111	111	111	111	111	111	111		111
Hot Air Flow (scfm)	46	46	46	46	46	46	46	42	44	45		52
Test Oil Flow (gpm)	2	2	2	2	2	2	2	2	2	2	START OF RESTART PERIOD	2
Total Seal Leakage (scfm)	12.5	11.5	10.6	11.9	10.8	12.8	13.6	10.6	11.1	12.3		8.5
Test Bearing Outer Ring (°F)	640	640	640	640	650	650	650	650	650	660		640
Test Bearing Inner Ring (°F)	640	630	630	640	650	640	640	650	650	650		620
Roller Bearing Outer Ring (°F)	550	550	550	550	560	555	560	560	560	560		540
Oil Seal Housing (°F)	—	—	—	—	—	—	—	—	—	—		—
Air Seal Housing (°F)	985	970	970	970	980	985	975	970	970	830		1010
Test Bearing Housing (°F)	690	690	690	690	700	700	705	710	700	710	END OF TEST PERIOD	685
Roller Bearing Housing (°F)	560	570	570	565	560	560	560	565	570	560		540
Air Seal Bellows (°F)	800	790	790	790	790	790	790	780	790	670		840
Hot Air in Manifold (°F)	1210	1200	1190	1200	1200	1205	1200	1200	1200	1150		1200
Oil Inlet (°F)	515	520	520	520	525	520	520	520	530	530		520
Oil Outlet (°F)	540	540	540	540	545	540	545	545	550	550		530

TEST CONDITIONS

The majority of the total seal leakage was across the oil seal.

The oxygen content in the test bearing chamber was 0.011%.

TEST BEARING # 267110

OIL USED MOBIL XRM 109F, MOBIL XRM 127B + 10 % BY WGT KENDEX 0839 DATE 6/17-18/68

RUNNING TIME, HOURS	38.5	39.5	40.5	41.5	42.5	43.4	43.8	44.8	45.8	46.8	47.8	48.8
SPEED, RPM	14	14	14	14	14		14	14	14	14	14	14
AIR MANIFOLD PRESS. (PSI)	106	106	106	106	106		106	106	106	106	106	106
BEARING CAVITY PRESS. (PSI)	6-7	6-7	6-7	6-7	6-7		6-7	6-7	6-7	6-7	6-7	6-7
SEAL CAVITY PRESS. (PSI)	111	111	111	111	111		111	111	111	111	111	111
HOT AIR FLOW (SCFM)	46	46	46	46	46		45	45	45	45	45	45
TEST OIL FLOW (GPM)	2	2	2	2	2		2	1.75	1.75	1.75	1.75	1.75
TOTAL SEAL LEAKAGE (SCFM)	11.9	11.9	10.6	11.4	10		23	24	23	23	30	30
TEST BEARING OUTER RING (°F)	645	650	650	650	650		650	660	650	650	650	640
TEST BEARING INNER RING (°F)	645	650	650	650	650		640	640	635	635	640	640
ROLLER BEARING OUTER RING (°F)	550	550	550	555	550		515	550	570	545	555	540
OIL SEAL HOUSING (°F)	—	—	—	—	—		—	—	—	—	—	—
AIR SEAL HOUSING (°F)	1000	995	1000	1000	1000		870	910	915	910	925	905
TEST BEARING HOUSING (°F)	680	685	690	690	690		600	620	630	610	620	610
ROLLER BEARING HOUSING (°F)	560	565	565	565	565		530	590	610	590	600	530
AIR SEAL BELLOWS (°F)	815	810	810	815	810		650	685	705	690	705	680
HOT AIR IN MANIFOLD (°F)	1200	1200	1200	1200	1200		1130	1170	1170	080	1170	1170
OIL INLET (°F)	520	520	520	520	520		514	540	515	525	525	500
OIL OUTLET (°F)	540	540	540	540	540		490	530	545	525	535	515

STOP: BROKEN N_2 LINE RESTART

TEST CONDITIONS

TEST BEARING # 267110

OIL USED MOBIL XRM109F, MOBIL XRM127B, +10 wt% BY WGT KENDEX0839 DATE 6/18/68

RUNNING TIME, HOURS	49.8	50.8	51.8	52.8	53.8	54.7	55.7	56.7	57.7	58.6	58.7	
SPEED, RPM	14	14	14	14		14	14	14	14	14		
AIR MANIFOLD PRESS. (PSI)	106	106	106	106		106	106	106	106	106		
BEARING CAVITY PRESS. (PSI)	6-8	6-8	6-8	6-8		6-7	6-7	6-7	6-7	6-7		
SEAL CAVITY PRESS. (PSI)	111	111	126	111		111	111	111	111	111		
HOT AIR FLOW (SCFM)	52	46	46	46	RESTART	48	46	46	46	46	COMPLETED	
TEST OIL FLOW (GPM)	1.75	1.75	1.75	1.75		1.75	1.75	1.75	1.75	1.75		
TOTAL SEAL LEAKAGE (SCFM)	19.1	24.2	19.5	22.9		22.5	21.6	21.4	21.6	19.2		
TEST BEARING OUTER RING (°F)	650	650	650	650		650	650	650	650	650		
TEST BEARING INNER RING (°F)	645	660	650	660		650	650	650	650	650		
ROLLER BEARING OUTER RING (°F)	560	560	560	560		510	515	520	530	500		
OIL SEAL HOUSING (°F)	—	—	—	—		—	—	—	—	—		
AIR SEAL HOUSING (°F)	980	930	1005	970	..	950	960	960	960	960		
TEST BEARING HOUSING (°F)	645	660	675	680	STOP	640	655	660	660	660	TEST	
ROLLER BEARING HOUSING (°F)	560	570	585	565		535	550	550	550	550		
AIR SEAL BELLOWS (°F)	755	705	790	755	END OF	730	740	740	740	740		
HOT AIR IN MANIFOLD (°F)	1200	1180	1200	1200		1195	1200	1200	1200	1200		
OIL INLET (°F)	520	520	520	520		505	505	505	505	505		
OIL OUTLET (°F)	540	540	540	545		520	520	525	525	530		

TEST CONDITIONS

The majority of the total seal leakage was across the oil seal.

The oxygen content in the test bearing chamber was 0.01%.