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LIFE TEST OF
 LIQUID METAL LUBRICATED THRUST BEARING

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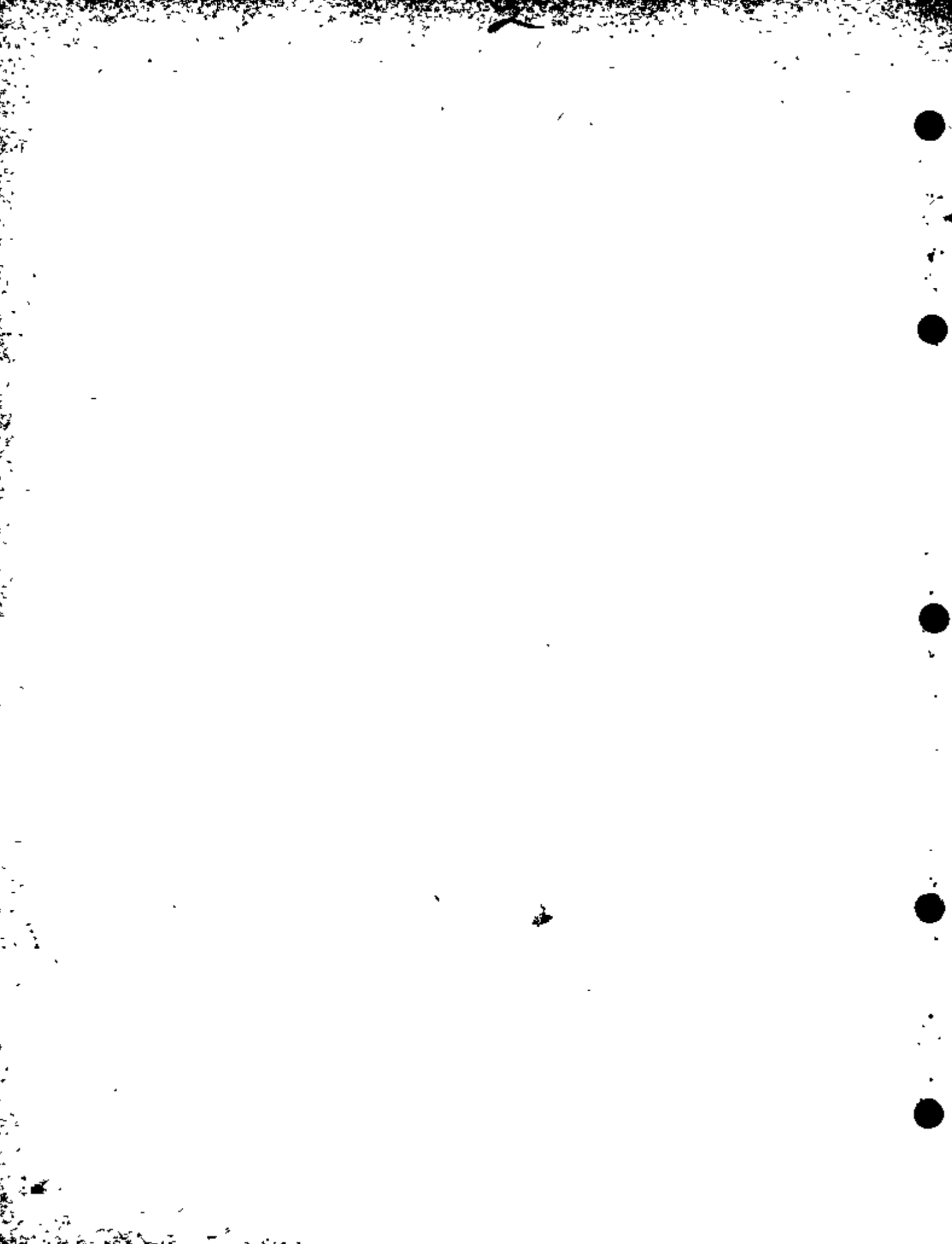
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5

KAPL-521

CONTENTS

	<u>Page</u>
Introduction	7
Conclusions	7
Procedure	9

692 2

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6



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7

LIFE TEST OF LIQUID METAL LUBRICATED THRUST BEARING

by D. B. Vail

INTRODUCTION

In the development of liquid metal lubricated bearings a life test of 2700 hours duration was performed on the Carboloy tapered-land thrust bearing. A description of the design of the bearing and the test equipment is included in General Electric Company Report No. R50GL231, "Investigation of Liquid Metal Lubricated Bearings" by H. Apkarian. The purpose of this test was to operate the bearing under conditions at least as severe as those encountered in normal pump operation.

The liquid metal used as a lubricant during this test was analyzed as 58.2% potassium and 41.8% sodium with 0.006% oxygen at room temperature.

CONCLUSIONS

1. At the end of 2700 hr of operation there was no evidence of depreciation in the load-carrying capacity of the hydrodynamic lubricating film of liquid metal. It is more probable that an increase in the load-carrying capacity occurred. A comparison may be made to the minimum value of the bearing parameter $2N/P$ given in the report mentioned in the Introduction, "Investigation of Liquid Metal Lubricated Bearings." This investigation was an incomplete study of the maximum capacity of the bearing. The minimum value obtained was $2N/P = 3.2$, whereas during the present testing, values as low as 1.5 were obtained, which signifies approximately double the bearing load capacity. This improvement may in part be attributed to satisfactory operation of the self-aligning spherical housing, which gave improved alignment, and to a more complete determination of the maximum load-carrying capacity. At no point during the test was hydrodynamic lubrication impaired by the hard particles of Stellite 6, which were accidentally introduced into the bearing lubricant under circumstances noted below.

2. Visual examination of the bearing following completion of the test indicated that no damage was incurred during testing. A small polished band on the inner periphery of the bearing and a similar polished area on one land indicated that the bearing surfaces, which are not perfectly flat, were in contact.

Concern has been expressed as to the hydrodynamic operation or surface damage of a tapered-land thrust bearing under conditions of hard metallic contamination of the liquid metal. During this test a Stellite 6 welded journal with 18-4-1 high-speed tool steel guide bearing failed causing very deep scoring and copious removal of the Stellite material. The position of this guide bearing may be noted in report R50GL231. The Stellite was introduced to the bearing by the circulating liquid metal. Minute particles of the Stellite were welded to or imbedded in the Carboloy. These particles show as light spots in photographs 1092973 and 1092974.

An examination of the bearing indicates that the original lapping marks have not been removed during testing. This denotes that the wear of material is insignificant. Prior to testing, the upper bearing surface measured 1.0 μ in. RMS using a profilometer, whereas after the life test an average reading of 3.0 μ in. RMS was recorded. A similar increase from 2.1 to 4.7 μ in. RMS average surface finish was noted on the lower bearing surfaces.

3. Summary of performance

Total time in liquid metal	3290 hr
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Operational time above 750°F	130 hr
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at 750°F	1430
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300 to 750°F	740
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below 300°F	380
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Total operational time	2680 hr
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Operational time above 500 lb load	30 hr
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at 500 lb load	2630
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below 500 lb load	20
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Total operational time	2680 hr
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Operational time above 900 rpm	50 hr
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at 900 rpm	1880
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at 600 rpm	190
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at 450 rpm	90
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at 300 rpm	450
------------	-----

below 300 rpm	20
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Total operational time	2680 hr
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Total number of stops above 500 lb load 26
at 500 lb load 197
at 70 lb load 35
at 500 lb load 197
70 lb load 61

Total number of stops and starts 258

PROCEDURE

The test was conducted with a thrust bearing of approximately 40 sq inches. The upper or plane bearing is constructed of Carboloy grade 55A, while the lower or five-tapered-land bearing is constructed of Carboloy grade 779.

Excluding a few initial and final check runs, the bearing supported a load of 500 lb during the operational time.

After a few hours of operation the liquid metal temperature was increased gradually to 850°F. This temperature was decreased to 750°F since this was the design point for the tester. Approximately one temperature cycle per week was performed. During this period the temperature was decreased at a rate of 1°F per min to a minimum of 300°F.

During the test period the tester was stopped and started 197 times with a load of 500 lb and stopped 26 times with loads up to 2000 pounds. The usual period of shutdown with load was 1 hr, although several periods of longer duration and a few of several minutes duration were incurred. The stops and starts without external loading totaled 35. The 70 lb supported during these stops are the dead weight of the shaft and bearing.

Photograph 1092973 of the lower or tapered-land bearing and photograph 1092974 of the upper bearing were taken following the completion of the life test. A polished area may be noted on the inner periphery of both bearing pieces. Another polished area is present on one of the lands of the lower bearing half.

Following the completion of 2500 hr of life testing a series of runs was made at various temperatures and speeds to determine the load-carrying capacity of the bearing. The initial runs in this series, as shown on curve AV-1023, were taken with a ZN/P bearing parameter of approximately 3 or higher. It is to be noted that the 2000-lb limit is the limit of the test equipment and not the maximum capacity of the bearing. Curve AV-1024 is a plot of the data taken immediately preceding unstable or boundary lubrication and thus presents the maximum capacity of the thrust bearing. The reproducibility of these points was satisfactory since only a variation of 5 to 10 rpm or 10 to 15 lb with a

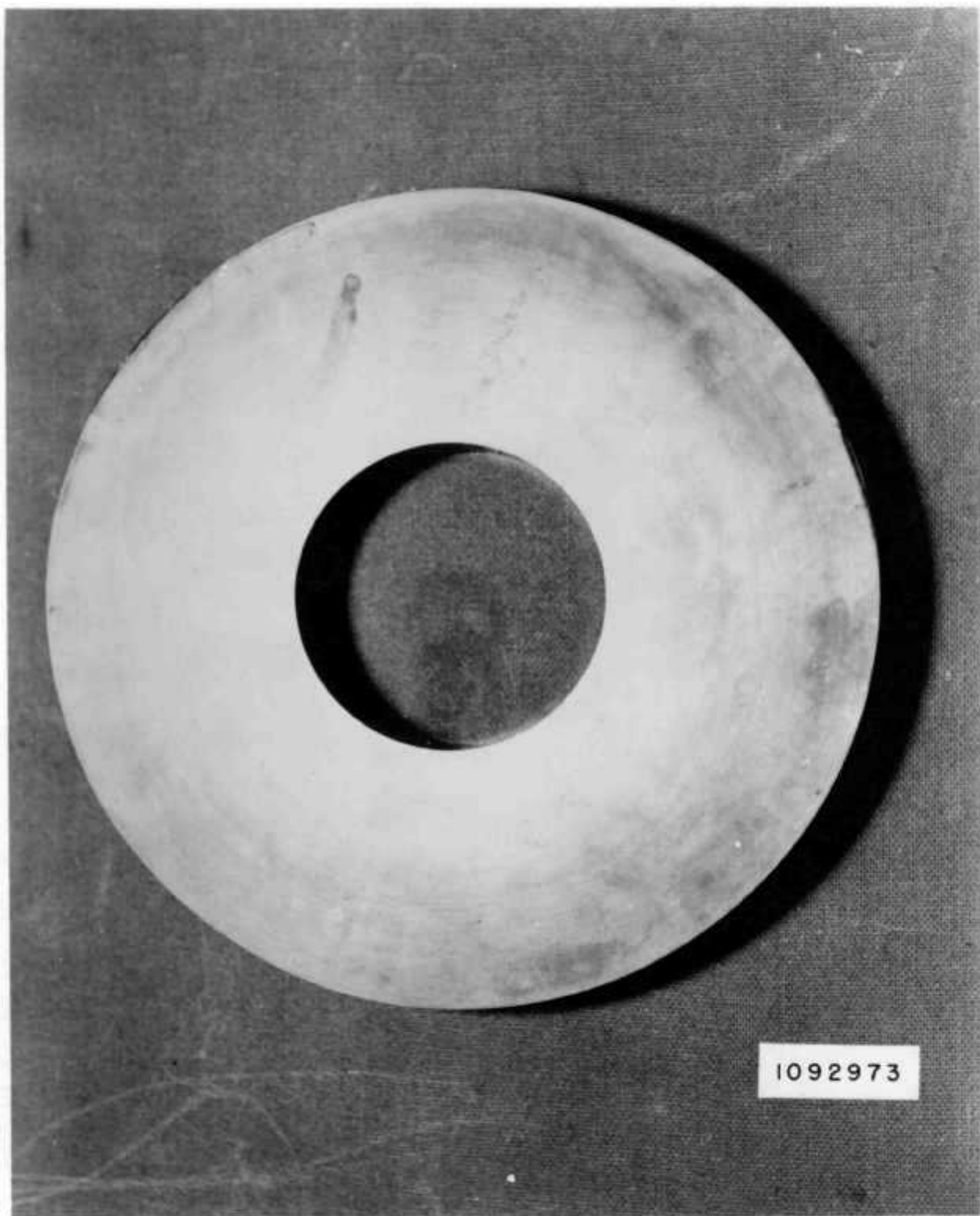
constant temperature was apparent. The minimum value of the bearing parameter ZN/P obtained was 1.5 but the majority of the values of ZN/P were 2 or higher.

SUMMARY

The Carboloy thrust bearing has shown satisfactory hydrodynamic properties with liquid metal lubrication and has proven its indestructibility under loads normally encountered in pump design.

11

Pg. 11-12

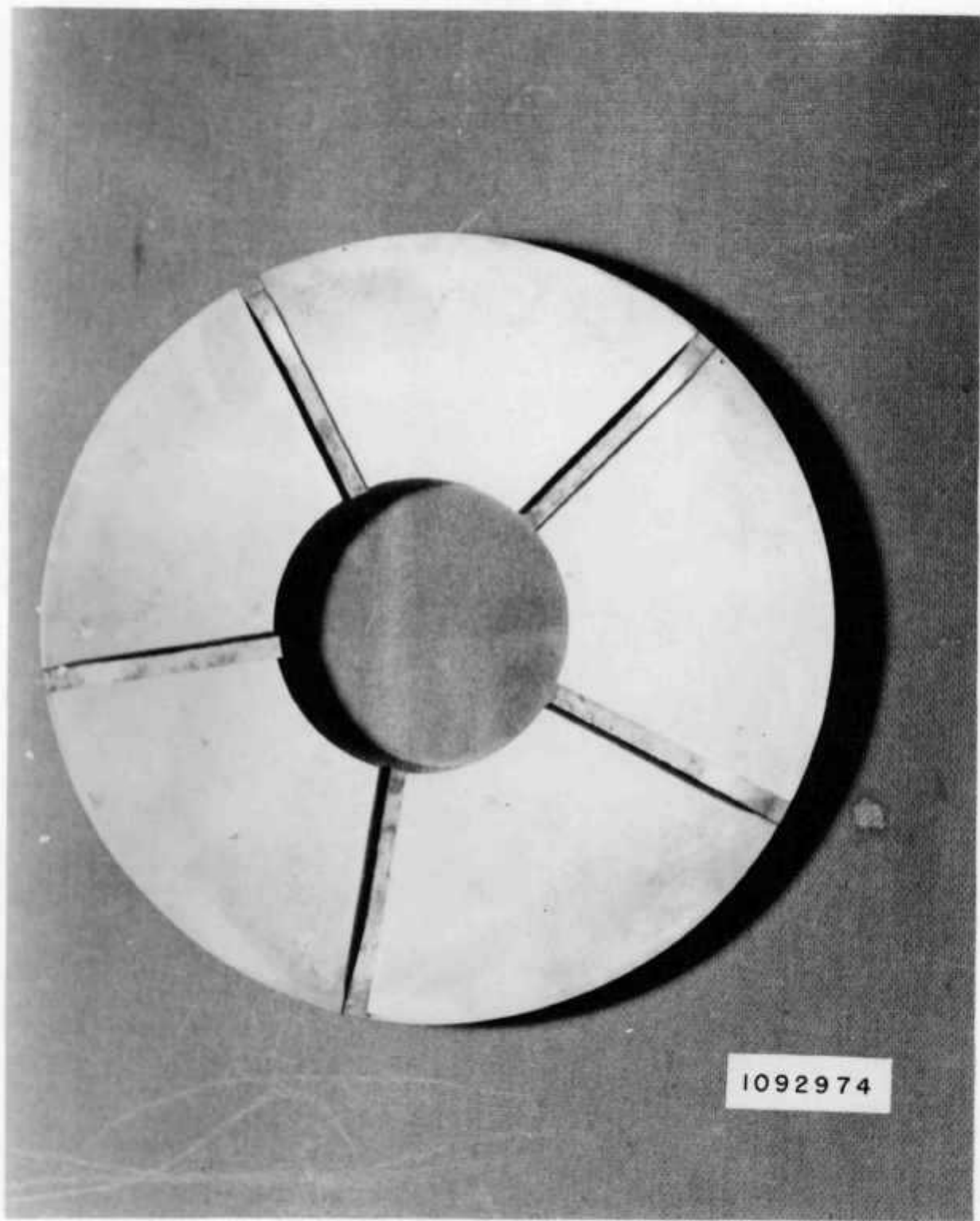


1092973

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Pg. 13-14



1092974

092 008

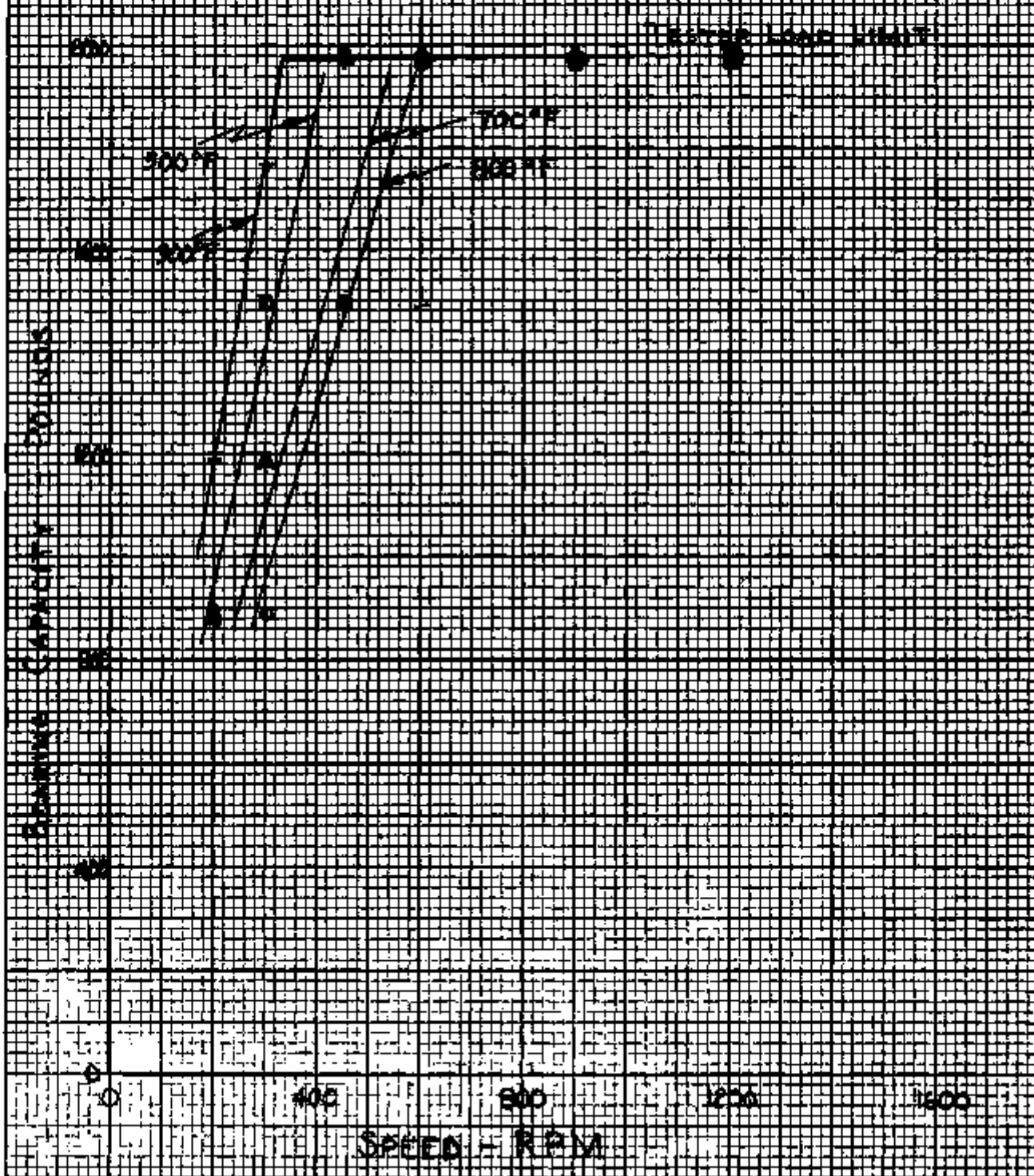
TAPERED LAND THRUST BEARING CAPACITY

DIAMETER $\frac{3}{4}$ " \pm .003 OR HIGHER

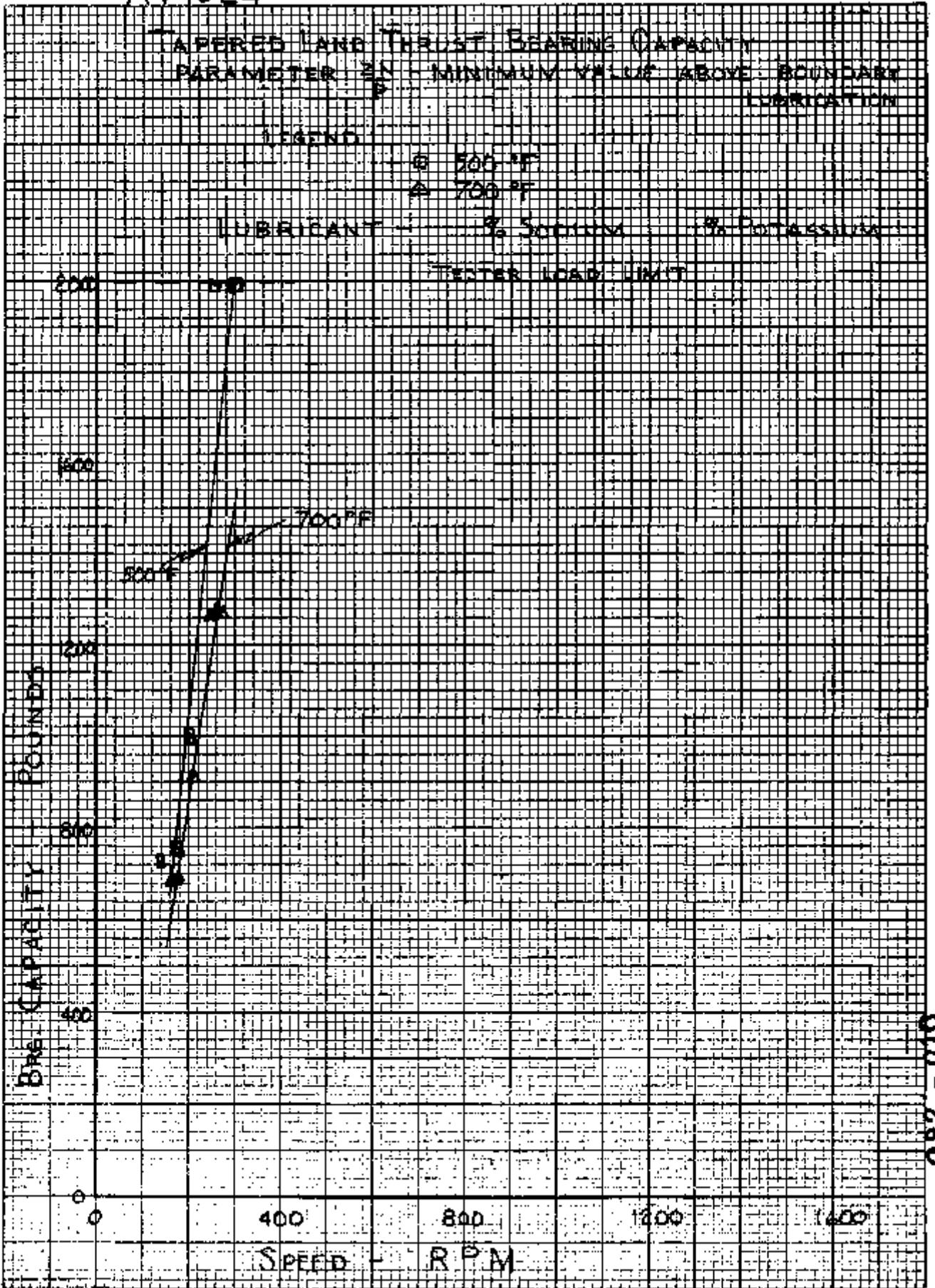
LUBRICANT - 2% SODIUM - 2% POTASSIUM

LEGEND

- 160°F
- ▲ 200°F
- △ 240°F
- 280°F



AV-1024



092-010
760