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DRY BEARING ENDURANCE TEST
FOR THE SERVICE MACHINE

EXPERIMENTAL GAS-COOLED REACTOR

Contract No. AT(10-1)-925

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DRY BEARING ENDURANCE TEST
FOR THE SERVICE MACHINE

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DRY BEARING ENDURANCE TEST

I. INTRODUCTION

The service machine of the Experimental Gas-Cooled Reactor consists of a pressure vessel which contains mechanisms for servicing the reactor. The service machine is mounted on a bridge and carriage in a limited-access area located above the reactor vessel. Access to the reactor core is gained through nozzles provided in the top head of the reactor pressure vessel. Helium coolant passes from the service machine into the reactor vessel to maintain the mechanisms within the service machine at or below design-temperature limits. In order to prevent contamination of the reactor coolant, the bearings and gears of the service-machine mechanisms must be unlubricated or sealed in pressure-tight containers. The design of the service machine employs unlubricated bearings and gears.

II. OBJECTIVE

The concept of operating bearings and gears unlubricated in a helium environment has been questioned as to fundamental soundness.

Theories of bearing and gear actions include such items as wear protection by metallic oxide films. Other theories envision welding, cracking, spalling, or other forms of immediate gross or catastrophic, i.e., a "sudden death" type of failure as a result of non-lubricated operation in a helium environment even at very low speeds and negligible loads.

The purpose of this test was to determine if immediate gross failure occurs. If such failure does not occur, then presumably some reasonable operating life, though greatly reduced from lubricated life, can be expected for non-lubricated bearings operating in a helium environment. However, this test was not intended to establish what a reasonable life would be. This test was further not intended to establish the sufficiency of any specific service-machine component nor to prove anything about the design of the machine. It was anticipated that gradual wear would occur, at a high rate.

III. CONCLUSIONS

- A. A bearing of standard manufacture was operated in helium for 42 hours. A high degree of gradual wear was encountered. No gross or sudden failures were found.
- B. The high rate of wear generates large amounts of debris. It will be necessary to examine the design of the service machine to insure that accumulations of debris do not increase the wear rate.
- C. This test reveals nothing fundamentally unsound in the general approach of operating unlubricated bearings in dry helium. The absence of lubrication, of course, requires that the speeds and loads be greatly reduced, but does not necessarily result in immediate, gross, or sudden failure.
- D. This test proves nothing about the design of the service machine. Later recommendations will deal with the necessary proof tests at service-machine design conditions.

IV. TEST EQUIPMENT

The test equipment consisted of:

1. A radial drill press
2. Dillon force gauge - 2500-lb capacity
3. Helium bottle
4. Manometer - 36-inch
5. Container and seal (Figure 3)
6. Valves and tubing to connect the apparatus
7. Last word dial indicator.

V. TEST SPECIMEN

Two bearing specimens were tested, New Departure 909640-909540 thrust ball bearings. The first test utilized the complete bearing, while the second test was performed with the ball retainer removed. An extra ball was added to fill part of the space left after removal of the retainer.

VI. TEST PROCEDURE

A. Inspection of Specimens

A visual inspection for defects in the ball-bearing specimens showed the bearings to be outwardly sound and well-made.

B. Inspection of Equipment

A comprehensive inspection was made of the test equipment during fabrication and assembly. The parts were hand-fitted and operated before testing. The complete assembly was checked for gas leakage.

C. Preparation for Tests

Two tests were run, one on each bearing. Before each test the following preparations were made:

1. The bearings were operated for 2 hours in grease to burnish working bearing components.
2. After burnishing, the specimen and equipment were de-greased in successive baths of carbon tetrachloride, detergent, and acetone.
3. Weights were attached to the vertical feed lever of the drill press. The Dillon force gauge was placed under the chuck of the drill press to measure thrust load so that the proper weights could be selected.
4. The base plate of the bearing container, together with the outer race, was fastened with clamps to the bed of the drill press. A dial indicator was then fastened in the chuck of the drill press. The bearing container plate was shifted and shimmed to ensure that the outer race bearing surface was perpendicularly aligned and centered with relation to the rotating shaft of the drill press.

5. The helium bottle, valves, tubing, manometer, and other incidental components of the bearing container were then assembled with low pressure helium. The container was purged for approximately 4 minutes. After purging, the seal cup was filled with mercury to effect a helium seal. Internal pressure was adjusted to 7 inches of water.

D. Test Operation

The bearings were axially loaded with a 350-lb thrust load and rotated at 325 rpm. The operating cycle consisted of operating the bearing for 8 to 9 hours each day. A check of the specimen was conducted every 5 minutes. Helium pressure, noises, or any visible changes were monitored. The helium pressure in the bearing container was limited to 7 inches of water or less by the mercury seal design.

VII. RESULTS

The first bearing tested was complete with a ball retainer. This bearing operated under load for 18 minutes before freezing occurred. The damage occurred when the balls pushed the retainer ring outward, causing the retainer to wedge between the balls and the outer race. The balls and race, being harder than the retainer, were undamaged (Figure 1).

The retainer was removed from the second bearing. One ball from the previous bearing was inserted to make up for some of the space left between the balls. This bearing was operated for 42 hours. At the end of 42 hours, a loud, high-pitched noise had developed in the bearing and the test was discontinued. Upon inspection of the bearing components the balls were found to be out of round and discolored (Figure 1). Steel powder, which had collected in the bottom of the cavity (Figure 2), appeared to be damp. The origin of the dampness was not determined. However, it is believed that mercury vapor may have accumulated inside the cavity during bearing rotation. This may be attributable to the heat generated by the bearing.

VIII. DISCUSSION

The first bearing with retainer lasted only 18 minutes, while the second bearing (less retainer) had not failed at the end of the 42-hour operation period - conclusive proof that ball-bearing retainers should not be used in bearings designed to operate non-lubricated in a helium environment.

The second bearing produced enough heat to raise the temperature of the container to 180 F. To insure that no mercury vapor would escape into the surrounding atmosphere, a water cover was placed on top of the mercury. Temperature variations were also made evident by the increase in internal pressure as the operation time increased. Internal pressure was controlled closely to prevent blow-out of the seal. There were intervals of approximately 16 hours between periods of bearing operation. During shut-down, the apparatus transferred its accumulated heat to the ambient air. As a consequence, the internal pressure was reduced to less than atmospheric pressure during the shut-down interval.

Figure 1, Front Row: Balls (1st bearing); Balls (2nd bearing).
Note discoloration and out-of-round shape of balls at right.

Back Row: Inner Race, Ball Retainer (1st bearing); Inner Race
(2nd bearing)
Note distortion of retainer at mid plane.

Figure 2, Front Row: Inner Race, Seal Cavity, Rotating Shaft, and Seal
(2nd bearing).

Back Row: Bearing container with outer race installed.
Note steel powder inside.

FIGURE 3

DATA SHEET
DRY BEARING TEST

1ST BEARING TEST

DATE	START	STOP	TOTAL TIME	LOAD	R.P.M.	REMARKS
5/12/60	1:30 P.M.	1:48 P.M.	18 MIN.	350#	325	BEARING WITH RETAINER JAMMED AFTER 18 MIN. OF GREASELESS RUN

2ND BEARING TEST

DATE	START	STOP	TOTAL TIME	LOAD	R.P.M.	REMARKS
5/13/60	4:00 P.M.	5:00 P.M.	1 HOUR	350#	325	
5/16/60	8:45 A.M.	5:15 P.M.	8 HRS. 30 MIN.	350#	325	
5/17/60	9:45 A.M.	5:15 P.M.	7 HRS. 20 MIN.	350#	325	TWO STOPS @ 5 MIN. FOR MAINTENANCE
5/18/60	8:30 A.M.	5:15 P.M.	8 HRS. 30 MIN.	350#	325	15 MIN. STOP FOR MAINTENANCE
5/19/60	8:40 A.M.	5:10 P.M.	8 HRS. 30 MIN.	350#	325	
5/20/60	8:25 A.M.	5:10 P.M.	8 HRS. 45 MIN.	350#	325	

TOTAL TIME OF TEST: 42 HRS. 35 MIN.

REMARKS: AT THE TIME OF SHUT DOWN BEARING WAS STILL OPERATING.

SIMILAR TO

DR'N <i>J. Janych</i>	CH'D	APP'D	SCALE = 12	SHEET OF	ISSUE
ALLIS-CHALMERS MFG. CO.			DEPT.		

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