SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP5448/3

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Plain Bearing Low Speed Oscillation Test

1. SCOPE:

1.1 Purpose:

This test method outlines a standard procedure for performing unidirectional load dynamic testing of self-lubricating bearings at room temperature, elevated temperature or sub-zero temperature, dry or contaminated with fluids. The wear data from these tests is to be used for qualification and to establish bearing design criteria.

1.2 Classification:

Bearings covered by this test method shall be plain spherical bearings, which are self-aligning or plain sleeve bearings.

2. REFERENCES:

There are no referenced publications specified herein.

3. DEFINITIONS:

Not applicable.

4. GENERAL REQUIREMENTS:

4.1 Test Apparatus:

4.1.1 Test Machine: The test machine shall be capable of applying a unidirectional load of controlled magnitude to the bearing race while the ball (for spherical bearings) or shaft (for sleeve bearings) is oscillated through a prescribed angle. Loads shall be capable of being maintained within +3%/-0% of the test requirement. Angle of oscillation shall be capable of being maintained within ±0.5° of the test requirement. The bearing shall be mounted to place the shaft in double shear with a minimum of bending. The machine should include the following accessory equipment for complete testing capability.

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http://www.sae.org/technical/standards/ARP5448/3

4.1.1.1 Bearing Holders: Appropriate size bearing holders shall be made of steel. Provisions to bush these holders are recommended.

4.1.1.2 Test Shafts: Appropriate size test shafts shall be made of steel with a hardness of Rc 45 minimum or Cres, PHI3-8Mo, condition H-950, and may be chrome plated or nickel plated. When testing sleeve bearings, it is acceptable for some test machine setups to require bushings to act as an inner race. All further statements about shafts shall also apply to shaft/bushing combinations. Cres is recommended for shafts because of its increased fatigue properties. Shafts for testing sleeve bearings shall have 8 Ra surface finish on the outside diameter and be polished after grinding.

4.1.1.3 Temperature Heating System: A temperature heating system shall permit heating the test bearing to a controlled temperature at the ball liner interface for spherical bearings or shaft liner interface for sleeve bearings. One approach to accomplish this when testing spherical bearings is to grind a small groove in the test bearing ball or race face and tack weld a thermocouple in it. When sleeve bearings are tested, an inner sleeve or bushing slightly wider than the bearing with similarly attached thermocouple acts as the inner. Locate the thermocouples within ±45° of the center of the load zone. Temperature monitors/controllers shall be accurate within ±5 °F.

4.1.1.4 Temperature Cooling System: A temperature cooling system shall permit cooling the test bearing to a controlled temperature at the ball liner interface for spherical bearings or shaft liner interface for sleeve bearings. The preferred system consists of an insulation box around the test station and introduction of N_2 or CO_2 as a cooling medium. Temperature shall be monitored/controlled as in 4.1.1.3.

4.1.1.5 Radial Displacement Indicator: A dial indicator or electronic pickup device, accurate within 0.0002 inch, shall be mounted to permit measurement of any radial movement of the race with respect to the ball for spherical bearings or radial movement of the journal with respect to the shaft for sleeve bearings. The preferred system is to measure bearing holder displacement with respect to the test shaft. The next preferred method is to measure bearing holder displacement with respect to some fixed surface. The least preferred method is measurement at some remote site.

4.1.1.6 Liquid Contaminator System: A liquid contaminator system shall introduce liquid contaminants to each side of the test bearing during dynamic testing. This system shall have provisions to accurately regulate the flow rate of the contaminant. Provisions shall also be made to catch the fluids.

4.1.1.7 Cycle Counter: Provisions shall be made to count cycles.

4.1.1.8 Load Monitor: Provisions shall be made to monitor load.

4.1.1.9 Torque Monitor: Provisions shall be made to monitor torque to rotate the test spindle for reference purposes. It is advisable for the test laboratory to have previously determined the torque attributable to the support bearings of the test rig spindle in order to isolate torque due to the test bearings.

4.1.2 Calibration: Calibration of the instrumentation shall be in accordance with manufacturer's specifications and shall be within limits at the time of the test.

4.1.3 Equipment Variations: Variations to the test equipment and associated methods required herein are permissible provided the procuring activity is provided with sufficient calibration data to verify the accuracy of the test conditions/results.

4.2 Test Specimen:

Spherical bearings shall be prepared for testing by notching or otherwise permanently marking the outer race to identify the center of load zone. If the temperature control method specified in 4.1.1.3 is utilized, spherical bearings shall be prepared for elevated temperature testing by grinding a notch in one ball or race face and attaching an appropriate thermocouple in it. Sleeve bearings shall have the center of the load zone identified on the metallic sleeve.

5. DETAILED REQUIREMENTS:

5.1 Procedure:

The test bearing shall be installed in an appropriate bearing holder with a mark identifying the center of the load zone.

Fit between bearing O.D. and holder shall be 0.0000 to 0.0010 clearance fit for spherical and 0.0000 to 0.0010 interference fit for sleeve bearings. Fit between bearing I.D. and shaft for both spherical and sleeve shall be 0.0000 to 0.0010 clearance fit.

The bearing holder, bearing and shaft shall be installed in the bearing test machine and mounted to place the shaft in double shear with a minimum of bending. Bearing support and adapter bushings should be tight against the ball face of spherical bearings, but clamp up on the ball need not be controlled provided it is not excessive. Dial indicator or electronic pickup device shall be installed.

The specified oscillating load shall be applied and held statically for 15 minutes minimum. At the end of this time the dial indicator or electronic pickup device shall be "zeroed."

The test shall be run in such a manner, that the ball for spherical bearings, or shaft and/or bushing of sleeve bearings, is oscillated ±X° minimum from the zero position. X° shall be stated in the test plan. A cycle shall consist of oscillation from zero to +X° and return to zero to -X° and return to zero. Rate of oscillation for ambient temperature tests shall be specified in the test plan.

The oscillation test shall be started. Readings of wear, temperature (for elevated and sub-zero tests) and cycle count shall be recorded at the beginning of the test and at sufficient intervals to plot a graph of wear (ten-thousandths of an inch) versus life (cycles). Upon completion of the test, the loaded breakaway torque shall also be measured if specified in the test plan.

5.2 Elevated Temperature Tests:

Testing at elevated temperature shall be as specified above except spherical bearings shall have a thermocouple attached to the ball or race as described in Section 4 and sleeve bearings require a sleeve bushing with a thermocouple attached as described in 4.1.1.3.

The bearing holder, bearing and shaft (and bushing for sleeve bearings) shall be installed in the bearing test machine and mounted to place the shaft in double shear with a minimum of bending. Thermocouple leads should be located within ±45° to the center of the load zone. Bearing support and adapter bushings shall be tight against the ball face of spherical bearings or bushings face of sleeve bearings, but clamp-up need not be controlled providing the ball is driven without slippage.

The temperature controller(s) shall be set at an adjusted temperature determined by calibration tests to guarantee that the test temperature at the ball (or bushing)/liner interface will be maintained as close as practical to the specified test temperature without exceeding it. After the controller(s) are set, allow a minimum 30 minutes for the temperature to stabilize.

Rate of oscillation for elevated temperature tests shall be specified in the test plan.

5.3 Sub-zero Temperature Tests:

Testing at sub-zero temperature shall be as specified in 5.2 except that the bearing shall be cooled during the test by introducing N_2 or CO_2 gas into an insulated box surrounding the test station. The oscillation rate is optional except that the minimum shall be 5 CPM. Intermittent operation of the test machine is allowable if necessary to counteract the effects of frictional heating.

After temperature controllers are set, the bearing shall be allowed to cold soak at the temperature for a minimum of 30 minutes after which time oscillation may start.

5.4 Fluid Compatibility, Immersion Method:

Test bearings shall be wiped with isopropyl alcohol to remove any fingerprints or oil film and immersed for 24 hours in the test fluid at 160 °F ± 5 °F, exception: some fluids may chemically decompose, evaporate, or simply not be intended for 160 °F applications, therefore lower the soak temperature to their recommended maximum safe use.

Within 30 minutes after removal from the test fluid, the bearing shall be tested as specified in 5.1.

5.5 Fluid Compatibility, Drip Test Method:

Tests with liquid contaminants present shall be conducted at ambient temperature as specified in 5.1. Prior to the test, the bearings shall be wiped with isopropyl alcohol to remove any fingerprints or oil film. Flow shall be controlled as close as practical to introduce liquid contaminants at a rate to equal or exceed one drop per minute to each side of the test bearing.

6. NOTES:

6.1 Intended Use:

This test method is intended to provide a method to evaluate the performance of spherical or sleeve sliding self-lubricating bearings subject to unidirectional loads at room temperature, elevated temperature or sub-zero temperature and dry or fluid contamination conditions.

6.2 Method of Reference:

This test method shall be referenced in general and detailed specifications, standards or drawings for sliding bearings. Specific test and data requirements are given in the Appendix or referencing document. The following note shall be used to reference this test method:

NOTE: The bearings shall be tested in accordance with ARP5448/3. The slash number refers to this specific test method.

6.3 Test Data:

6.3.1 Test Parameters: Specific test requirements are given in the referencing document. Test requirements shall include the following test parameters as applicable:

a. Test specimen design envelope
b. Shaft and housing configuration
c. Loads
d. Oscillation and/or misalignment angles
e. Frequency of oscillation
f. Temperature requirements
g. Cooling and/or heating requirements
h. Fluid contamination
i. Test duration
j. Failure criteria (wear, loads, fluid contamination, etc.)

6.3.2 Data Requirements: Specific measurements required and the frequency of each measurement are given in the referencing document. Data requirements shall include the following measurements as applicable:

a. Time or cycles
b. Wear (*)
c. Temperature
d. Torque to rotate test spindle
e. Load Amplitude (if variable)
f. Frequency – cpm (if variable); CPM (Cycles Per Minute)

* NOTE: Wear should be recorded at sufficient intervals to provide a plot of wear versus life in cycles. Recommended data points are at approximately 0, 10, 50, 250, 1000, 5000 and 25,000 cycles and every 25,000 cycles thereafter. The bearing holder expands and contracts with temperature variation; therefore, the readings should be taken when the bearing holder heaters have completed their heating cycle.

6.3.3 Test Records: A log shall be maintained during the test and shall include a record of start and stop times, cycles accumulated, maintenance performed on the test facility and any other pertinent information relating to the test. Data indicating the progress of the test shall be recorded at sufficient intervals to produce an accurate plot of recorded test parameters versus hours. Data sheets shall be filled out when data is taken during the test. Test data sheets shall be in a format similar to the sample test data sheet shown in Figure 1. Readings from oscillographs, temperature controls or any other recording devices shall then be taken at specified intervals and the records maintained sufficiently to support reporting of the test results. After the test, the test bearing liner shall be inspected and the observations recorded.

6.3.4 Test Reports: The recorded data shall be summarized in report form and shall contain the following:

a. Bearing description

1. Part number
2. Lot identification
3. Manufacturer
4. A dated drawing completely describing the test bearing, the dimensions, materials, heat treatments, surface finish, liner system identification, if applicable, and the rating

b. Test machine description as applicable

1. Model number, serial number and a brief description
2. Calibration data
3. Photograph

c. Test parameters
d. For sleeve bearings only, data on shaft material, heat treatment and surface finish and process