



AEROSPACE RECOMMENDED PRACTICE

ARP5448™/2

Issued 2007-07
Reaffirmed 2026-03

Plain Bearing High Speed Oscillation Test

RATIONALE

ARP5448/2 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

1.1 Purpose

This test method outlines a standard procedure for performing cyclic reversing load testing on oscillating sliding bearings. The wear data from these tests is to be used for qualification requirements and to establish bearing design criteria.

1.2 Classification

Bearings covered by this test method shall be of spherical or sleeve (journal) configuration.

2. REFERENCES

There are no referenced publications specified herein.

3. DEFINITIONS

3.1 SLIDING VELOCITY

Sliding velocity is the result of displacement or movement of the rubbing surfaces at a given frequency of oscillation or misalignment.

3.2 PHASE RELATIONSHIP

The phase relationship is the angular difference between the location of the maximum load and the maximum sliding velocity with respect to the start of a cycle.

NOTE: The maximum sliding velocity occurs when the test specimen is at the center of its total displacement angle or at zero displacement. For example, "in phase" requires peak load to occur when the bearing has zero displacement (maximum velocity) and "90 degree out of phase" requires peak load to occur 90 degrees before or after the maximum sliding velocity when the bearing was at maximum displacement (zero velocity).

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4. GENERAL REQUIREMENTS

4.1 Test Apparatus

4.1.1 Test Machine

The test machine may be of any size or design but shall be capable of applying loads and motion to the bearings as defined in the referencing document. Instructions for operating and maintaining the test machine are required.

4.1.1.1 Design

The machine can test any number of bearings simultaneously providing it can be shown that all the bearings are being subjected to the same test conditions and all measured values can be individually determined. The structure, support bearings, drive motors and linkages should be designed for continuous operation and high reliability. The shaft and housing design for the test bearing shall allow oscillation of the shaft with respect to the housing. The shaft shall be placed in double shear and shall be supported to provide a minimum of bending.

4.1.1.2 Applied Load

The load can be applied by any means providing the magnitude of the peak to peak load and its location with respect to the start of a cycle is known and preferably adjustable. A load versus time curve, which approximates a sine wave, is desirable. Other types of load input, such as a square wave, are generally more severe and will cause greater wear of the test specimen.

4.1.1.3 Sliding Velocity

Displacement in the form of oscillation (movement about the connecting shaft or bolt centerline) or misalignment (movement about the remaining mutually perpendicular axes) can be input by any means, providing the magnitude of the oscillation or misalignment angle and its location with respect to the start of the cycle is known and preferably adjustable. The form of the displacement versus time curve shall approximate a sine wave. The frequency of oscillation or misalignment can be obtained by any means, providing the settings can be held constant and the values monitored.

4.1.1.4 Phase Relationship

The test machine must be designed to maintain specified phase relationships and provide adjustment when required.

4.1.1.5 Environmental Conditions

Unless required for specific tests, the automated control of temperature and application of fluid or solid contaminants is optional.

4.1.2 Instrumentation

The test machine shall be instrumented to measure the parameters listed in Table 1. This table also gives the accuracy required and indicates if the parameter should be measured continuously, measured as required while the test machine is running (dynamic), or measured while it is stopped (static). Instrumentation that will allow the test machine to operate unattended for up to 90 h is very desirable, but not required.

4.1.2.1 Wear Measurement

Provisions must be made in the design of the test machine to provide appropriate datum surfaces to measure wear of the test specimen. The procedure for measuring wear requires that the change in relative distance between the bearing shaft and housing be measured under a light gage load and at the maximum applied load (see 5.6). Using the frame of the test machine as a reference is acceptable providing the internal clearance of the support bearings is low and can be maintained at a near constant value throughout the test.

4.1.2.2 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 Safety Provisions

The test machine shall be protected to the extent necessary to provide safety to personnel supporting the test. In particular moving shafts, belts, chains and linkage should be shrouded or otherwise protected. Electrical controls should be housed in consoles to avoid shock hazards. Automatic shut-off should be provided for the test machine to detect mechanical, electrical or hydraulic problems that could endanger personnel or cause property damage due to fire, smoke or explosion.

4.1.4 Maintenance

A visual inspection of the test machine shall be performed prior to the start of the test and during each shutdown for wear measurements. It is desirable to have a general maintenance schedule and procedure to check and replace worn parts before the start of each test.

4.1.5 Quality Assurance

Provisions shall be made to verify and document that the following items have been checked and are acceptable.

- a. Operating instructions and maintenance procedures for the test machine are prepared and are understood by the test machine operator.
- b. Safety requirements have been met and no additional safety hazards exist.
- c. Test machine is operational and all required test parameters are within specified limits.
- d. All instrumentation is functional and within calibration limits.

4.2 Specimen

4.2.1 Test Bearing

The test bearing shall be as specified in the reference document. Manufacturer part number and serial number shall permanently identify each bearing.

4.2.2 Shaft and Housing

The shaft and housing shall be of the configuration required by the reference document. Part number and serial number shall permanently identify each housing. Unless otherwise specified, a close tolerance bolt (180,000-psi minimum) shall be used as a shaft for the bearing. The clearance between the bearing inner diameter and the bolt shall not be greater than 0.0015 in. The nut shall be torqued to provide maximum available clamping force through the faces of the ball.

4.2.3 Disposition of Test Specimens

The test bearings shall be removed from the housing and part numbers and serial numbers of both bearing and housing shall be verified. The housing may be reused following re-inspection for dimensions and condition. The test bearing shall be inspected and disposed in accordance with the reference document.

5. DETAILED REQUIREMENTS

5.1 Pretest Checkout Test

A test procedure, including a checklist, a list of data requirements and forms for recording data shall be prepared. A typical data sheet is shown in Table 2. Dummy bearings shall be installed to allow the test engineer and test machine operator to become proficient at running the test machine and recording data. Before starting the checkout test, a careful examination of the test set-up, test machine and instrumentation shall be conducted. Load and motion inputs should then be gradually increased to their final values. During this period, procedures and typical values for operating temperatures, wear measurements and operating torque can be checked and operating characteristics of the test machine can be assessed. The duration of the checkout test is at the option of the test engineer.

5.2 Test Specimen Installation

Part number and serial number shall permanently identify each bearing and housing. Record the bearing manufacturer's name and these identifying numbers and install the bearing into the housing. Permanently apply index marks on the bearing or housing to document the orientation of the assembly in the test machine. Insure that any thermocouple wires or other instrumentation is properly attached and install assembly into test machine.

5.3 Verification of Test Parameters

Scheduled inspections shall be made to verify that all values or conditions for each test parameter (see 6.3.1) are as specified and maintained during the entire test. Also verify that all measurements to be used for data requirements (see 6.3.2) are properly taken and within specified accuracy. These inspections shall be made at the start and completion of each test and at recurring intervals during the test. The frequency of the interim inspections should be based on experience with each specific test machine. A minimum of three interim inspections shall be made to verify load and oscillation or misalignment angle and interim inspections to verify frequency and phase relationship.

5.4 Cooling

If fan cooling is utilized to maintain the bearing housing temperature at a lower operating level, it shall be noted in the test report.

5.5 Contamination

As the ball of the bearing is oscillated, the contaminant shall be applied to both faces of each side of the bearing at the juncture of the stationary and oscillating surfaces.

5.6 Wear Measurements

If the reversing load is greater than the steady load, wear occurs on both the tension and compression side of the bearing liner and the total wear is the sum of the wear on each side. Wear measurements shall be taken in both directions at a gage load that does not exceed 10% of the peak load and at the peak load. Since the wear measurement at the higher load tends to be more repeatable, it can be used to verify the wear reading at the gage load. To assure accuracy, all readings must be repeated until the values for two consecutive readings agree within ± 0.0005 in.

As shown in Figure 1, wear values are determined by measuring C-D or B-A, both of which equal the "gap" or total slop in the bearing. Since the gap includes deflection and possible internal clearance of both the test and support bearings as well as bearing wear, the gap measurement at zero time must be carefully taken and subtracted from subsequent values to determine the actual wear.

During a test, wear of support bearings, control rod bearings, or any other mechanism, which could affect the test results, shall not exceed 10% of the maximum wear allowable of the test specimen. To satisfy this requirement, a solid rod end with no bearing shall be installed and C-D or B-A measurements taken and recorded before and after the test.

By using the sample formats and example shown in Tables 3 and 4, a comprehensive summary of the measured gaps, bearing wear on each side of the line total wear, and deflection of the bearing under maximum load is presented.

5.6.1 Wear Measurement Procedure

The following procedure shall be used to measure the reference height C and D (or A and B) shown in Figure 1. Record measured values on data sheet shown in Table 2.

1. Shutdown test machine by first removing load and then stopping the machine.
2. Position the bearing at zero displacement and misalignment.
3. Apply gage load with rod end in tension and measure reference height C or A.
4. Apply gage load with rod end in compression and measure reference height D or B.
5. Repeat steps 3 and 4 until readings agree within ± 0.0005 in.
6. Apply peak load in place of gage load and repeat steps 3 to 5.
7. Remove load and resume testing using normal start-up procedure.

5.6.2 Initial Wear Measurement

The following procedure is to be used to determine the initial deflection and clearance in the test gearing and test machine. Record measured values on the data sheet shown in Table 4.

1. Install solid rod-end and measure reference height per 5.6.1.
2. Install test specimen.
3. Start test machine and apply gage load with rod end in tension. Run for 30 s; remove load and shutdown test machine.
4. Repeat step 3 with rod end in compression.
5. Measure reference height per 5.6.1.

6. NOTES

6.1 Intended Use

This test method is intended to provide a method to evaluate the performance of spherical or sleeve (journal) type sliding bearings subject to cyclic reversing loads and oscillation or misalignment.