Designation: D 3337 – 91 (Reapproved 2002)

Standard Test Method for Determining Life and Torque of Lubricating Greases in Small Ball Bearings[1]

This standard is issued under the fixed designation D 3337; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method describes a procedure for the determination of grease life and torque in small bearings. Although this test method is not the equivalent of a long-time field-service test, it is intended to predict the relative grease life at high temperature in a reasonable period of testing time. In addition, this test method measures the running torque at both low (1 r/min) and high (12 000 r/min) speeds.

1.2 Except for torque, which is measured in g·cm, the values stated in inch-pound units are to be regarded as the standard in this test method. The SI values given in parenthesis are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *grease life*—a measure of the durability of the grease in a small bearing at elevated temperatures.

2.1.2 *grease torque*—a measure of the amount of friction due to viscous shear of the grease.

2.1.3 *running torque*—a measure of the amount of friction in a rotating bearing due to load, speed, and viscous shear of the grease.

3. Summary of Test Method

3.1 A single row ball bearing with the test lubricating grease is rotated at a high speed under a constant load and selected temperature. Total running time is determined at completion of the test as a measure of the durability of the grease.

3.2 Running torque can be obtained for a single row ball bearing with the test lubricating grease rotating at 1 r/min and 12 000 r/min.

4. Significance and Use

4.1 This test method is a screening test to differentiate among the expected life of greases in ball bearings running at high temperatures. If torque is a factor in selection of a grease, the test method provides for measurements at both low (1 r/min) and high (12 000 r/min) speeds.

5. Apparatus

5.1 The apparatus required for this test method is described in detail in Annex A1. A new R-4 bearing is used for each test. It is run at 12 000 r/min ½-lbf (2.2-N) radial load and 5-lbf (22-N) axial load.

6. Reagents and Materials

6.1 *Grease Sample*—Procure the grease sample from below the surface of the grease container. Do not let separated oil get in contact with the sample; pour the excess oil off if present. Screen the grease using a 40-μm retention filter. A technique for screening is described in Annex A2.

6.2 *Test Bearing*:

6.2.1 *Specifications*—the test bearing[2] is size R-4.

6.2.2 *Size*—0.2500 in. (6.350 mm) bore, 0.6250 in. (15.875 mm) OD, 0.1960 in. (4.978 mm) wide.

6.2.3 *Material*—Type 440C stainless steel, heat stabilized.

6.2.4 *Precision Class*—AFBMA (Anti-Friction Bearing Manufacturers Association) Class 7.

6.2.5 *Radial Clearance*—0.0003 to 0.0005 in. (0.007 to 0.013 mm).

6.2.6 *Retainer*—stainless steel ribbon type.

6.2.7 *Shields*—removable with snap rings.

6.2.8 *Packaging*—bearing, shields, and snap rings packaged individually in clean and sealed envelopes.

7. Grease Packing of Test Bearing

7.1 Pack the test bearing in a clean environment with a quantity of test grease to fill one third of the free space in the bearing.

[1] This test method is under the jurisdiction of ASTM Committee F34 on Rolling Element Bearings and is the direct responsibility of Subcommittee F34.02 on Tribology.

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[2] A suitable bearing is Barden No. SR4SSW4, shipped without lubricant and with shields and snap rings unassembled, available from O. P. Schuman and Sons, Inc., County Line and Titus Rd., Warrington, PA 18976.

7.2 If it is necessary to determine the free space of a weighed bearing, place the bearing (with shields and snap rings removed) in a container of melted petrolatum of known density under vacuum. Let the petrolatum harden, remove bearing, and replace shields and snap rings. Clean the bearing of excess petrolatum and determine the weight increase. Using the density of petrolatum and bearing weight increase, compute the bearing free space. For the Barden bearing No. SR4SSW4, the one-third free space is 0.080 mL.

7.3 The test bearing may be packed on either a weight or a volume basis. A small spatula or a small syringe[3] with a short needle can be used to place the test grease between the balls on both sides of the test bearing.

7.4 If the test bearing is packed on a weight basis, the density of the grease must be known in order to compute the weight of test grease equivalent to one-third the free space in the test bearing.

7.5 Immediately after packing the test grease in the test bearing, install the shields and snap rings. Then turn the bearing 100 revolutions in each direction at less than 200 r/min to distribute the test grease.

8. Procedure

8.1 This procedure describes removal of a used test bearing, installation of a new test bearing, start-up technique, and test monitoring.

8.1.1 *Test Bearing Removal*:

8.1.1.1 Remove the heater box.

8.1.1.2 Unlatch the radial and axial bead chains from the cantilever beams and unplug the test-bearing outer-race thermocouple cable from the post at the side of the tester.

8.1.1.3 Remove the nose cone by removing the four screws which attach it to the test-bearing housing.

8.1.1.4 Using two small wrenches, one on the test-bearing lock nut and one on the spindle flats next to the nut, loosen the test-bearing lock nut. This is done safely by having the wrench handles about 20 deg apart and squeezing them toward each other to avoid a bending moment on the overhung end of the spindle.

8.1.1.5 Remove the test-bearing lock nut.

8.1.1.6 Slide the test bearing housing off the end of the spindle and lift slowly in a vertical direction until the torque arm, its bead chain, and the thermocouple wires with plug clear the slot in the mounting plate. Do not remove the slinger.

8.1.1.7 Push (Note 1) the used test bearing out of its housing.

NOTE 1—A ⅜-in. (9.5-mm) diameter by 6-in. (150-mm) long wooden dowel with one end turned down to ¼ in. (6.4 mm) diameter for 3⁄16 in. (4.8 mm) is useful in pushing out the test bearing.

8.1.1.8 Rotate the outer race of the used test bearing by hand to determine roughness, stickiness, etc. Tag the bearing, noting date, run number, grease code, running hours, and condition of bearing.

8.1.2 *Test Bearing Installation*:

8.1.2.1 With the spring-loaded thermocouple retracted, push a new test bearing into the housing. Use the nose cone to seat the test bearing fully. This avoids thumb pressure on the inner race and shields which can damage the bearing.

8.1.2.2 Hold the housing up above the tester and let the thermocouple plug with wires and the radial bead chain drop down through the slot in the mounting plate. **Caution:** Use care to ensure that the transducer-core extension is not bumped and that the thermocouple lead wires are not bent to prevent erroneous data.

8.1.2.3 Slide the test bearing and housing over the end of the spindle until the test bearing seats against the slinger.

8.1.2.4 Insert the thermocouple plug and attach the radial bead chain to its cantilever with three beads below the beam.

8.1.2.5 Install the test-bearing lock nut (Note 2) finger tight with the shoulder end toward the test bearing. Then fully tighten the nut using two small wrenches and following the technique in 8.1.1.4.

NOTE 2—If the test bearing runs at temperatures above 300°F (150°C), lubricate the nut and screw threads with a solid lubricant such as molybdenum disulfide to prevent thread galling.

8.1.2.6 Attach the nose cone with the bead chain slot upward using the four small screws.

8.1.2.7 Attach the axial bead chain to its cantilever beam with three beads beyond the beam.

8.1.2.8 Using a 0 to 5-lbf (0 to 22-N) spring scale, check the cantilever beams (Note 3) for ½-lbf (2.2-N) radial loading and 5-lbf axial loading.

NOTE 3—Cantilever beam loads can be changed by bending the beams. After bending, use a 6-in. (150 mm) machinist square and a straightedge to ensure that the radial-bead chain is perpendicular to the base and that the axial bead chain is in line with the centerline of the spindle.

8.1.2.9 Check the thermocouple lead wires to be sure they are freely suspended and smoothly contoured from the torque arm to the plug.

8.1.2.10 Carefully place the heater box over the test-bearing housing.

8.1.3 *Start-up Technique*:

8.1.3.1 To relieve drive-belt tension, prop up the pivoted-drive motor using a block of wood.

8.1.3.2 Turn the run-time meter to zero.

8.1.3.3 Set the cycle timer to 20 % (zero to 17 % is the 4-h shutdown interval).

8.1.3.4 Set the torque-meter cut-off at 80 % of full scale.

8.1.3.5 Set the temperature controller (left-hand pointer) to about 20°F (10°C) below the intended outer-race test-bearing temperature. Set and maintain the over-temperature cut-off (right-hand pointer) 15°F (9°C) above the control temperature (the temperature controller is connected to the thermocouple in the heater box).

8.1.3.6 Turn on the following switches: 110 V a-c, torque, heater, and high-speed motor. Then push the start button to activate circuits.

8.1.3.7 Gradually slide the prop out from under the drive-motor base until the spindle runs at low speed with a slack belt. Finger pressure on the spindle aids in keeping a low speed. Run for about ½ min at low speed before removing the prop to bring the spindle up to test speed.

[3] A suitable micrometer syringe is Catalog No. N-07844-00, 0.2-mL capacity, manufactured by Cole-Parmer Instruments Co., 7425 North Oak Park Ave., Chicago, IL 60648.

TABLE 1 Suggested Report Form for Evaluation of Greases in Small Bearings

Grease:		Date:	
Temperature, °F (°C)		Operator	
Speed, r/min			
Load, lb: Radial		Avg running-life from	
Axial		three runs, h	

Run No.	Torque g-cm Minimum 1 r/min	Minimum High r/min	Failure High r/min	Outer Race, °F(°C) Rise	Box Control,° F (°C)	Running Life, h	Reason for Failure
1							
2							
3							
4							

8.1.4 *Test Monitoring*:

8.1.4.1 After 1 h of test operation at high speed and control temperature, measure the temperature[4] of the outer race of the test bearing. Adjust the controller such that the outer race of the test bearing is at test temperature for the grease. Additional controller adjustment may be required during the first 40 h of operation.

8.1.4.2 After 2 h of test operation at high speed and control temperature, stop the drive motor and prop it up to remove belt tension. Adjust the torque table so that the torque meter reads two to four units up-scale (torque-meter tare) by gently tapping the bead chains with a pencil during the torque table adjustment to minimize the torque-meter tare error due to static friction in the bearings. This ensures torque-transducer contact with the torque arm. Restart the testers and run for another hour before recording data.

8.1.4.3 Record test hours, torque-meter tare, torque-meter reading, net torque, torque in g·cm from calibration curve, control temperature, and outer-race temperature of the test bearing at least once every 24 h. Calibration of torque instrumentation is in A1.5. Torque data for both high-speed and one-r/min operation are to be recorded. After the first recording, set the torque meter cut-off at five times this running torque.

8.1.4.4 To keep the tester running for 30 s when over-torque occurs at start-up, hold the arm away from the transducer core by light finger pressure on the radial bead chain.

8.1.4.5 During the early part of the test at high speed, excessive bead-chain vibration, torque fluctuation greater than ±2 g·cm, or torque greater than twice the normal running torque for the grease may be observed. If any of these occur, stop the test and restart using a new test bearing.

[4] A miniature recorder with a chart speed of ¼-in./h is useful for monitoring outer-race temperature throughout the entire test. To set the controller, the outer-race temperature of the test bearing should be measured to ±2°F (±1°C) using a precision instrument such as a potentiometer.

9. Results

9.1 Termination of the test is determined by any one of the following conditions:

9.1.1 Instantaneous over-torque of five times the minimum running torque at high speed and test temperature, or over-torque of five times the minimum running torque if it continues for more than 30 s at high-speed start-up in the test cycle.

9.1.2 Over-temperature of 20°F (11°C) at the outer race of the test bearing.

9.1.3 Noise level increase that persists for more than 1 min either at start-up or running at high speed.

10. Report

10.1 Report test results and test conditions on the report form shown in Table 1.

11. Precision and Bias

11.1 The precision of this test is not known to have been obtained in accordance with currently accepted guidelines (for example, in Committee D-2 Research Report RR: D02-1007, Manual on Determining Precision Data for ASTM Methods on Petroleum Products and Lubricants).

11.2 Grease life data generated in cooperative testing using this procedure show appreciable scatter and were found to conform in the general case to Weibull probability distributions rather than normal distributions. Conventional ASTM definitions of repeatability and reproducibility are meaningful only for data that can be described by normal distributions and, therefore, are not appropriate. Weibull parameters such as slope, L_{10} and L_{50}, are used to describe the distribution of the test data.

11.3 Precision may be judged from Fig. 1 and Fig. 2, which are Weibull plots of the data obtained in test programs

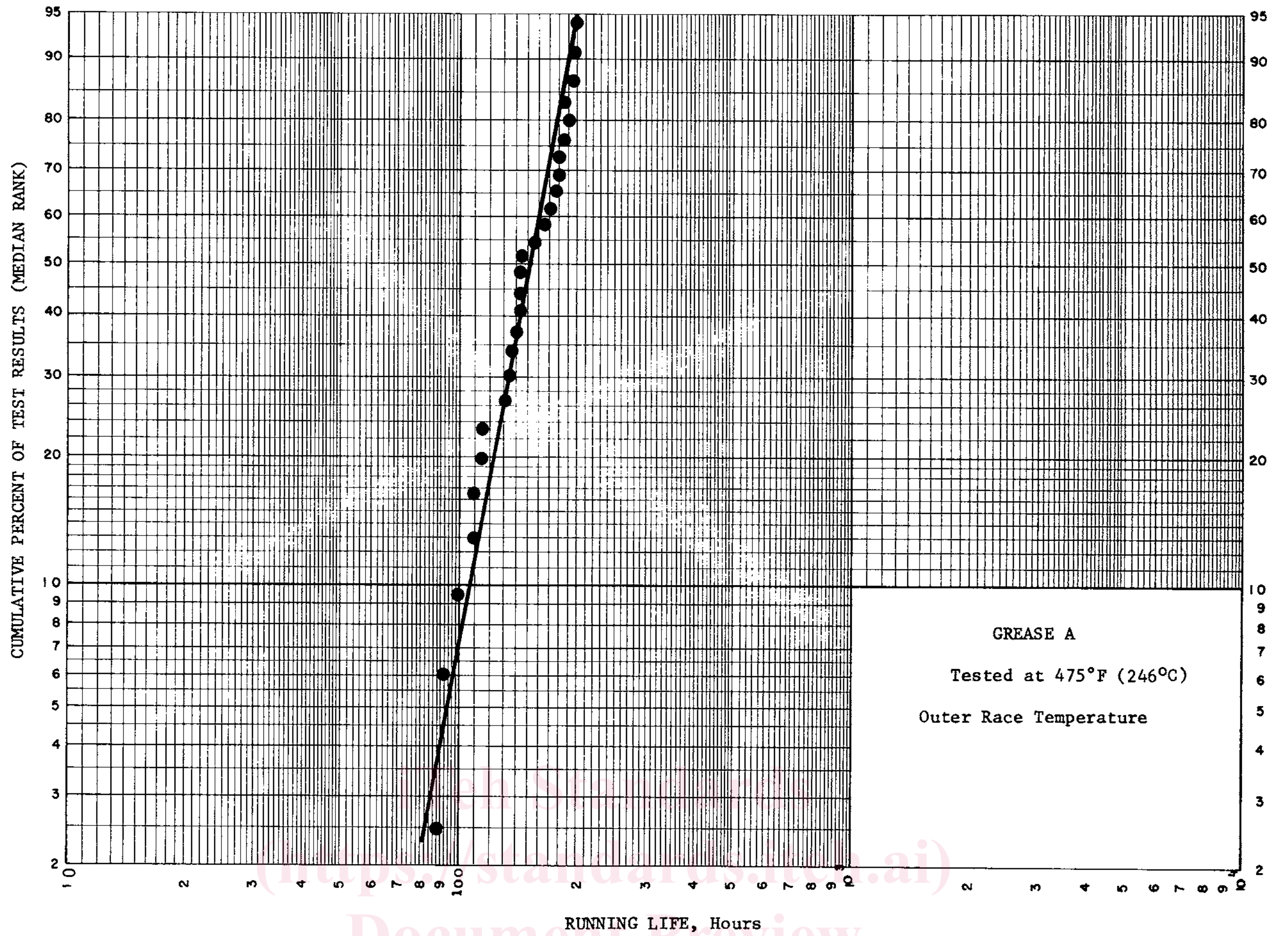

FIG. 1 Weibull Parameter of Grease A

involving two greases and seven cooperators. Weibull parameters calculated for the data are summarized in Table 2.[5]

TABLE 2 Precision—Summary of Weibull Parameters (Figs. 1 and 2)

	Grease A	Grease B
Weibull Slope	4.91	3.02
90 % confidence limits	3.88 to 6.24	2.26 to 4.10
L_{10} life, h	108	170
90 % confidence limits	89 to 117	112 to 204
90 % confidence limits, as percent of L_{10}	82 to 108	66 to 120
L_{50} life, h	153	296

11.4 The precision of the test may also be judged by considering Table 3, which summarizes the data obtained in the cooperative program.

TABLE 3 Precision—Summary of Cooperative Testing Program

	Failure Lives, h	
	Mean	Range for Center 50 % of Results
Grease A	151	130 to 180
Grease B	297	220 to 388

11.5 Because the life results obtained show appreciable scatter, replicate testing is essential when using this procedure.

11.6 *Bias*—The procedure in this test method for measuring grease life in small ball bearings has no bias because the value of grease life in small ball bearings is defined only in terms of the test method.

12. Keywords

12.1 lubricating grease; lubricating grease life; lubricating grease torque; running torque; small ball bearings

[5] Further details may be found in an article by Lindeman, et al., *NLGI Spokesman*, Vol 34, No. 4, July 1975, pp. 126–134.