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BUREAU OF INDIAN STANDARDS

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भारतीय मानक मसौदा

स्नेहक की घिसाव निवारक विशेषताओं का निर्धारण (चार-गेंद विधि)

Draft Indian Standard

DETERMINATION OF WEAR PREVENTIVE CHARACTERISTICS OF LUBRICANTS (FOUR-BALL METHOD)

(ICS 75.100)

Methods of Sampling and Test for Petroleum and Related Products of Natural or Synthetic Origin (excluding bitumen) Sectional Committee, PCD 01	Last date for comment **16 June 2024**

FOREWORD

(*Formal clauses to be added later*)

This standard provides a procedure to determine the wear-preventive characteristics of lubricants using the four-ball method. The standard is applicable for determining the wear-preventive attributes of the liquid lubricants and greases of mineral, biological, and synthetic origin.

In the preparation of this standard, considerable assistance has been derived from the following standards:

ASTM D 2266 Standard test method for wear preventive characteristics of lubricating grease (Four-Ball Method)

ASTM D 4172 Standard test method for wear preventive characteristics of lubricating fluid (Four-Ball Method)

ISO 20623 Petroleum and related products — Determination of the extreme-pressure and anti-wear properties of lubricants — Four-ball method (European conditions)

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off it shall be done in accordance with IS 2: 2022 'Rules for rounding off numerical values (*second revision*)'.

1 SCOPE

The standard prescribes the test method for determining the wear resistance characteristics of lubricants (oil and grease) in a steel-on-steel sliding contact. It is not recommended to determine extreme pressure and frictional characteristics of lubricants. The standard recommends steel-on-steel combinations, and no other metal combinations are intended to predict the wear characteristics. The standard recommends and utilizes all the values to be reported in SI units. The standard does not address any safety issues associated with using test protocol, test apparatus or solvents, chemicals, and test specimens. The user may follow appropriate safety norms and practices as found suitable.

2 TEST SUMMARY

The test is performed on a four-ball wear tester using four 12.7 mm diameter steel balls arranged as a tetrahedron. The bottom three balls are housed inside the ball pot filled with the lubricant to be tested. The fourth ball is clamped in the spindle with the help of a ball chuck and allowed to rotate at a speed of 1200 rpm. The top ball is pressed on the bottom three balls with a contact load of 392 N. The lubricant temperature is maintained at 75 °C throughout the test duration of 60 min. The wear preventive characteristic of the lubricant is reported in terms of average wear scar diameter obtained from the bottom three balls.

3 APPARATUS

3.1 Four-Ball Wear-Tester

A Four-Ball Wear Tester is a dedicated test rig that can hold the four steel balls of 12.7 mm diameters in the arrangement, as shown in Fig 1. The test rig has the provision to (i) heat the lubricant at 75 °C, (ii) load the contact with 392 N, and (iii) rotate the top ball (spindle) at 1200 rpm. The test rig should have appropriate instrumentation, control, data acquisition, and alarm systems for safe operation. The lubricant heater should have proper controls to stabilize the temperature within the prescribed limits while performing the test.

NOTE — A Four-Ball EP Tester is not recommended for wear tests, as an EP tester uses heavier loads and the test rig experiences jerks at weld load. Therefore, it lacks the required sensitivity recommended for wear tests.

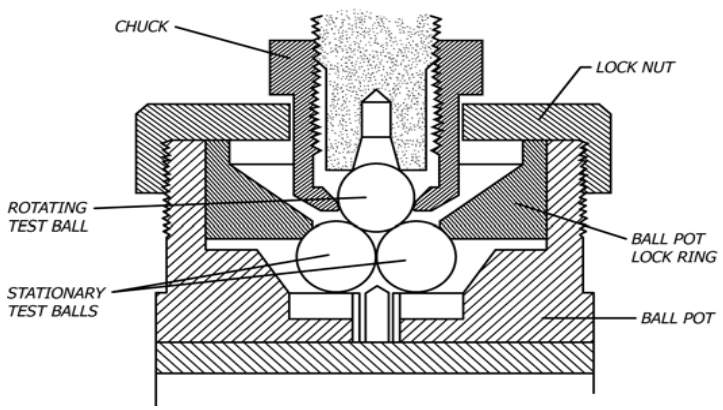

FIG. 1 FOUR-BALL ARRANGEMENT IN A WEAR TESTER

3.2 Microscope

A microscope capable of measuring the diameter of wear scars generated on the bottom three stationary balls to an accuracy of 0.01 mm after the test.

4 MATERIALS AND REAGENTS

4.1 Test Balls

The test balls used for conducting the tests should be Chrome alloy steel balls made from AISI standard steel no. E-52100. The balls should have a 12.7 mm diameter, Grade 25 EP (Extra Polish), and Rockwell C hardness of 64 – 66.

4.2 Cleaning Fluids

The cleaning fluids used for cleaning the test specimens and the apparatus should be non-toxic and nonflammable. The cleaning fluids should be capable of removing dirt, dust, rust, oil and grease traces from the surfaces of the test specimens and the apparatus. However, the cleaning fluids should not remove the coatings/polish of the samples and apparatus.

5 TEST CONDITIONS

The operating conditions used for conducting the test are:

Sl. No.	Parameter	Values
(1)	(2)	(3)
i)	Load	(392 ± 2) N
ii)	Speed	(1200 ± 60) rpm
iii)	Lubricant Temperature	(75 ± 2) °C
iv)	Test Duration	(60 ± 1) min

6 TEST PREPARATIONS

6.1 Switch ON the Four-Ball Wear Tester and set the drive/motor to obtain the 1200 ± 60 rpm spindle speed.

6.2 Clean the ball pot, ball chuck and the test ball specimens with the cleaning fluid and dry them using appropriate means (oven, clean, dry cloth, tissue paper or industrial wipe). If required, the ultrasonic vibration technique may be used for cleaning.

6.3 Set the temperature controller of the test rig to maintain the lubricant temperature at (75 ± 2) °C.

6.4 Set the test duration of (60 ± 1) min either using a programmable computer or an automatic timer.

6.5 Set up the loading mechanism (Pneumatic, Hydraulic, or Mechanical/Leaver-arm) to zero dead weight with all the parts and lubricant in position.

7 TEST PROCEDURE

7.1 Insert a clean and dry test ball in the ball chuck. Insert the ball chuck into the spindle and tighten it appropriately. Run the spindle momentarily and check for looseness, if any.

7.2 For Liquid Lubricants

Assemble three test ball specimens in the ball pot and lock the ball position using the locknut. Tighten the locknut by applying the torque of 67.7 Nm with the help of a wrench. Fill the ball pot with the liquid lubricant so the three balls remain immersed in the oil (3 mm below the oil surface). Ensure that the test oil fills all the void spaces in the ball pot and that the oil level of 3 mm above the ball surfaces persists.

7.3 For Lubricating Greases

Put a small amount of grease in the ball pot to fill all the void spaces between the balls to be inserted and the bottom of the ball pot. Assemble three test ball specimens in the ball pot and lock the ball position using the locknut. Tighten the locknut by applying the torque of 67.7 Nm with the help of a wrench. Fill the ball pot with the grease and level it up to the top surface of the locknut.

7.4 Place the ball pot assembly in the machine and apply the load slowly. Avoid shock loading. Wait till the steady load of (392 ± 2) N is applied to the contact.

7.5 Put on the lubricant heater and allow the lubricant temperature to reach (75 ± 2) °C.

7.6 Start the drive motor and allow the top ball to rotate at (1200 ± 60) rpm. The top ball forms sliding contact with the bottom three balls.

7.7 Switch off the drive motor after completion of test duration of (60 ± 1) min. Switch off the lubricant heater and unload the ball contact. Allow the assembly to cool down.

7.8 Remove the ball pot from the machine and measure the wear scars on the bottom three balls to an accuracy of ± 0.01 mm.

7.9 Wear Scar Measurement

7.9.1 *Measurement in the clamped position*

Drain/Wipe the lubricant from the ball pot and wipe the scar surface using tissue paper. Measure the wear scar diameter using an in-situ/inclined microscope specially designed for measuring the wear scar diameter over the test balls in the clamped position. Make two measurements over each ball in the horizontal and vertical directions. Report the average of the six measurements as the wear scar diameter in millimeters.

7.9.2 *Measurement in unclamped position*

Remove the balls from the ball pot. Wipe the balls clean with the help of tissue paper. Measure the wear scar diameter using a microscope. Make two measurements at 90 ° each on every ball

(one along the striations and the other perpendicular to it). Average the six wear scar readings and report it as the wear scar diameter in millimeters.

NOTE — If the average of two measurements on one ball varies from the average of all six readings by more than 0.04 mm, investigate the alignment of the bottom three balls with the top ball.

8 REPEATABILITY AND REPRODUCIBILITY

8.1 Repeatability

The difference in two successive results obtained by the same operator, using the same apparatus, under similar operating conditions, on identical test material should not exceed the following value:

Repeatability = 0.12 mm wear scar diameter difference

8.2 Reproducibility

The difference in two single and independent results from different operators in different locations on identical test material should not exceed the following value:

Reproducibility = 0.28 mm wear scar diameter difference

9 REPORTING

Report the average of the six wear scar diameter readings obtained from the bottom three balls as the wear scar diameter in millimeters.