

KES

Test Method of
Extreme-Pressure
for Lubricating Products

KES T-L044

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Contents

1. Scope of Application
2. Falex Method
3. 4-ball Method



1. Scope of Application

This standard specifies the evaluation method of the load-endurance for lubricating products like Falex, 4-ball, and tester methods.

2. Falex Method

2.1 Overview

This method is the evaluation method of the load endurance by Falex lubricant tester, and there are two of this.

2.2 Method in brief

Both methods have a steel journal that rotates at 290 ± 10 rpm about two V-blocks submerged in the sample.

The load is applied to the V-block by the Ratchet machine element.

In method A, the load increases uniformly, and in method B, the load is increased by manual operation every one minute starting from 250lb.

Both methods find the true load by calibration curve.

2.3 Meaning

Both methods shall be applied for the evaluation comparison of the load endurance.

2.4 Device

Falex Lubricant Tester:

Looks like in Figure 1 and 2, and 4500lb gage shall be used.

2.5 Material

2.5.1 Correction of the load gage

- (1) Allen screw: Connected to a 10mm Brinell ball.
- (2) Back-up plug
- (3) Standard specimen: Made of copper with BHN 37~39.
- (4) Brinell microscope
- (5) Stop watch
- (6) Steel: 150mm

2.5.2 Test Preparation

- (1) Standard V-block: angle 96 ± 1 , AISI C-1137 steel, HRC 20~24, surface roughness $5 \sim 10 \mu$ in

(2) Standard test journal:

Outer diameter 1/4in, AISI 3135 steel, HRB 87~91, surface roughness $5\sim 10\mu$ in

(3) Locking pin: Made of brass, 6½H Brass

(4) Benzene

2.6 Preparation of the true load calibration curve

Plot the load-diameter relation on the log-log graph paper in straight lines according to the following condition.

Table 1

Load(lbf)	Diameter(mm)
500	2.62
1000	3.42
1500	4.00
2000	4.47

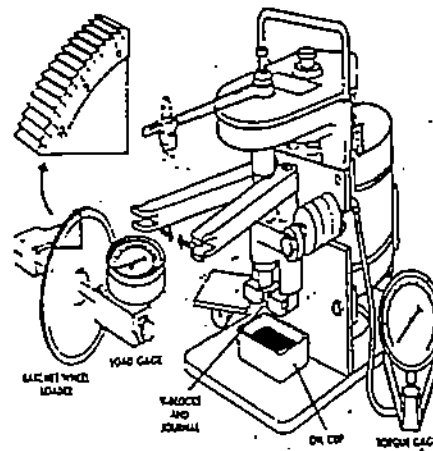


Figure 1 Falex Tester

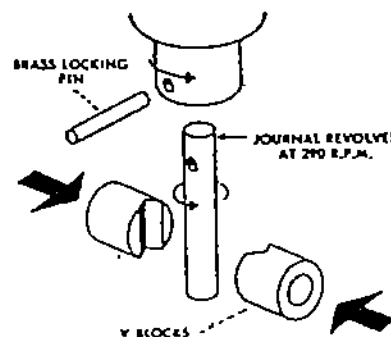


Figure 2 V-block and journal

2.7 Calibration(4500lbf) of Load gage

- (1) Loosen the Allen set screw and put a half in ball in the right jaw socket(See Figure 3).
- (2) Put a 10mm Brinell ball in the left and adjust the ball position to locate at 4mm above the surface.
- (3) Put the back-up plug in the left and adjust to locate at about 0.8mm above the surface.
- (4) Placing the standard test coupon as in Figure 3, and apply 500, 1000, 1500 and 2000lbf load and maintain it for one minute. And then measure the diameters of flaws on the test coupon at each loading conditions.

At this point, measure in the accuracy of 0.01mm.

- (5) Plot each load and the measured diameters on the true load graph.

This is the actual gage load. (The sample is in Figure 4)

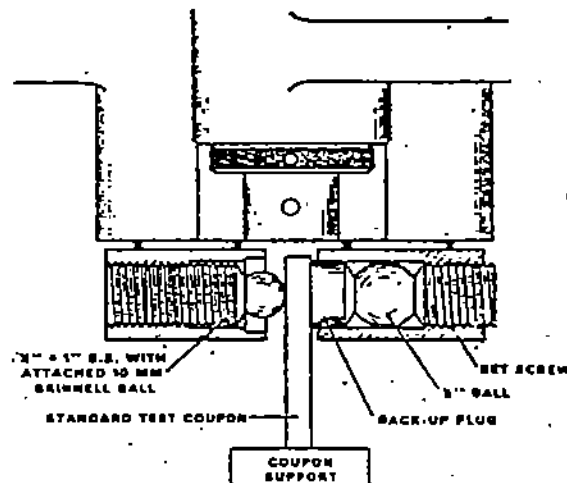


Figure 3 Calibration Curve Preparation Tester

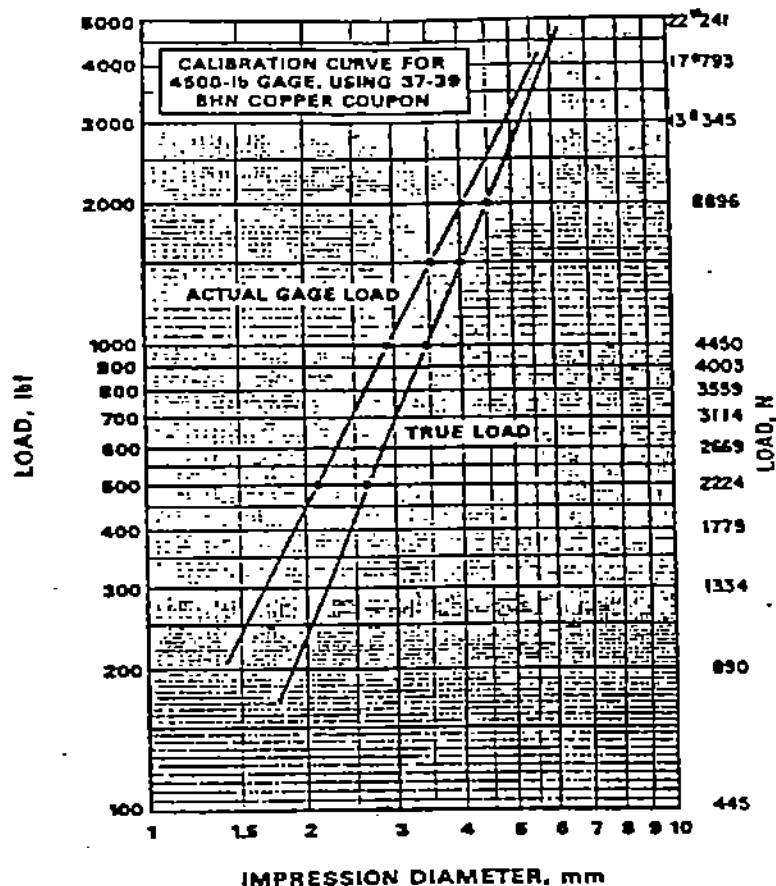


Figure 4 Sample load graph

2.8 Method A

2.8.1 True load gage determination at run-in

Manipulate as in 2.8.3, and the true load at run-in shall be 300lbf.

2.8.2 Device Mounting

(1) Cleansing

(A) Cleanse V-block, test journal, lubricant cup and V-block support with benzene, and dry until benzene volatilizes.

(B) Be careful not to touch the cleansed parts after cleansing.

(2) Device

(A) Fix the test shaft into the journal and settle with the brass locking pin.

(B) Insert the V-block in both sides and set to the journal.

(C) Putting 60ml of sample oil in the lubricant cup, put the cup

on and submerge the V-block in the sample liquid.

In case of heavy viscosity oil, shake it a little.

- (D) Equip the gage with jaw arms and set the automatic loading device.

2.8.3 Operation

(1) Run-in

- (A) Start the temperature controller to set the temperature of the sample to $51.7 \pm 3^\circ\text{C}$ and then turn off the heat switch.
- (B) Operate the Ratchet wheel manually and set the torque gage to "O".
- (C) Start a motor setting it automatic, and increase the true load up to 300lbf.

Operate at this load for 5 minutes.

(2) Test

- (A) Apply the load automatically to failure or 4500lbf.
 - (B) When it becomes to the failure or the 4500lbf load, stop the motor and record the failure load.
- However, if the failure does not occur at 4500lbf, record it as 4500+lbf.

- (3) Find the true load at failure by using the calibration curve.

2.9 Method B

2.9.1 Device mounting

Identical with the clause 2.8.2.

2.9.2 Operation

(1) Run-in

Identical with the clause 2.8.3 (1).

(2) Test

- (A) Apply the load up to 500lbf true load automatically.
- (B) Maintain the 500lbf load for one minute.
- (C) Add another 250lbf and maintain for one minute.
- (D) If no failure occurs, repeat to add another 250lbf and maintain one minute until the failure occurs.

2.9.3 Report for method A and B

Report by converting the failure load to the true load.

3. 4-ball Method

3.1 Scope of Application

This standard specifies the testing method of the load endurance mainly for the extreme pressure lubricating oils by measuring the load-wearing factor and the welding point with a 4-ball extreme pressure tester.

3.2 Overview of the testing method

Fix three test steel balls("fixed ball" below) on a sample vessel, and then putting a test steel ball("rotation ball" below) on it, rotate it at a speed of 1770 ± 60 rpm under the load. Set the sample temperature to $18 \sim 35^\circ\text{C}$ and continue the test increasing the load at every 10 second until melting occurs.

3.3 Meaning of Test

This test shall be performed to classify the pressure endurance of the lubricating oils into high, middle, and low levels, and this classification is not relevant to the usage.

3.4 Definition of Terminology

(1) Load-wear index(or load resistant performance of the lubricating oils)

This index indicates the performance of the lubricating oil preventing wear under specified load.

As for various test condition, apply relative kg loads having 0.1 spacing in log scale on the fixed ball and test 10 times until melting occurs.

The load-wear index calculation formula is shown in 9.

(2) Melting point⁽¹⁾

This means the minimum kg load that three fixed balls exert under various conditions specified in this test. This load starts the fixed balls to melt, and means that it is over than the limit pressure the lubricating oil can endure.

Note(1) Some lubricating oils does not cause melting, but print severe

wear marks on the fixed balls. In this case, report the load which shows a 4mm diameter in maximum of wear as the melting point.

(3) Corrected load

This means the kg load which is obtained by multiplying the load to apply in the test with the ratio between the Herz flaw diameter and the diameter of the measuring flaw under that load.

(4) Herz flaw diameter

This is the average diameter of flaws generated by the static loads applied in the test with the test conditions and can be obtained with the following expression.

$$D_h = 8.73 \times 10^{-2} (P)^{1/3}$$

where, D_h : Herz flaw diameter of the contact surface

P: Static load

(5) Compensation flaw diameter

Tested under specified load with the lubricating oil, this is the average diameter of scratched flaws generated on the hole of the fixed balls by the rotations balls, which does not burn to seize or melt to stick. However, even for the wear flaws which does not burn to seize or melt to stick, it is with in 5% of the values shown in line 3 of the Table 2.

(6) Herz line

This is the line drawn in the logarithmic graphs as in Figure 7, and shows the coordinates of flaw diameters(mm) and applied loads(kg) at static condition.

(7) Calibration curve

This is the curve drawn in the logarithmic graphs as in Figure 7, and shows the coordinates of flaw diameters(mm) and applied loads(kg) at dynamic condition. Calibration curve coordinates can be found in the line 1 and 3 of the Table 2.⁽²⁾

Note⁽²⁾ For some lubricating oils, coordinates appear above the calibration curve. This kind of liquids generally known includes methyl-phenyl-silicon, methyl-phenyl-dilicon-chloride, phenyl-ether, petrol-