**Designation: ~~D3233 – 93 (Reapproved 2014)~~ D3233 – 19**

# Standard Test Methods for Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Pin and Vee Block Methods)[1]

This standard is issued under the fixed designation D3233; 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.

## 1. ~~Scope~~ Scope*

1.1 These test methods cover two procedures for making a preliminary evaluation of the load-carrying properties of fluid lubricants by means of the Falex Pin and Vee Block Test Machine.

NOTE 1—Additional information can be found in Appendix X1 regarding coefficient of friction, load ~~gage~~gauge conversions, and load ~~gage~~gauge calibration curve.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*



## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

B16/B16M Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
D2670 Test Method for Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)
D2783 Test Method for Measurement of Extreme-Pressure Properties of Lubricating Fluids (Four-Ball Method)



## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *actual ~~gage~~gauge load, n*—the value obtained from the ~~gage~~gauge while running the test and before any corrections are made.

3.1.1.1 *Discussion—*

This ~~gage~~gauge reading is irrespective of the particular ~~gage~~gauge used, and corrections are made by comparison to a standard reference.

3.1.2 *direct load, n*—that which is applied linearly, bisecting the angle of the vee block corrected to either the ~~800~~800 lbf or ~~3000-lbf gage~~3000 lbf gauge reference.

3.1.2.1 *Discussion—*

This load is equivalent to the true load times the cos 42°.

[1] These test methods are under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.11 on ~~Tribiological~~Tribological Properties of Industrial Fluids and Lubricates.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

3.1.3 *true load, n*—the sum of the applied forces normal to the tangents of contact between the faces of one vee block and the journal pin corrected to the ~~4500 lbf gage~~ 4500 lbf gauge reference line.

3.1.4 *true load failure value, n*—the true load at which the lubricant tested can no longer support the applied load resulting in either test pin or shear pin breakage, or inability to maintain or increase load.

3.1.4.1 *Discussion—*

This value is also referred to as the limit of extreme pressure.

## 4. Summary of Test Methods

4.1 Both test methods consist of running a rotating steel journal at ~~290~~290 rpm ± ~~10 rpm~~ 10 rpm against two stationary V-blocks immersed in the lubricant sample. Load is applied to the V-blocks by a ratchet mechanism. In Test Method A (Note 1), increasing load is applied continuously. In Test Method B (Note 1), load is applied in ~~250-lbf (1112-N)~~250 lbf (1112 N) increments with load maintained constant for ~~1 min~~ 1 min at each load increment. In both methods the load-fail value obtained is the criteria for level of load-carrying properties. Both methods require calibration of the load ~~gage~~gauge and reporting of test results as true (corrected) loads rather than actual ~~gage~~gauge loads.

NOTE 2—Test Method A is referred to as the Falex Run-Up Test. Test Method B is referred to as the Falex One-Minute Step Test.

## 5. Significance and Use

5.1 Evaluations by both test methods differentiate between fluids having low, medium, and high levels of extreme-pressure properties. The user should establish any correlation between results by either method and service performance.

NOTE 3—Relative ratings by both test methods on the ~~reference~~ fluids covered in Table ~~1~~X2.1 and Table ~~2~~X2.2 are in good general agreement with four-ball weld-point relative ratings obtained on these same ~~reference~~ fluids, covered in Test Method D2783.

## 6. Apparatus

6.1 *Falex Pin and Vee Block Test Machine,*[3] illustrated in Fig. 1, Fig. 2, and Fig. 3, fitted with ~~4500-lbf (20 000-N) gage or 3000-lbf (13 350-N) gage.~~4500 lbf (20 000 N) gauge or 3000 lbf (13 350 N) gauge.

6.2 *Required for Calibration:*

6.2.1 *Allen Screw,* with attached ~~10-mm~~10 mm Brinnell ball.[4]

6.2.2 *Back-Up Plug.*[4]

6.2.3 *Standard Test Coupon,*[4]soft, annealed copper, Hb 37–39.



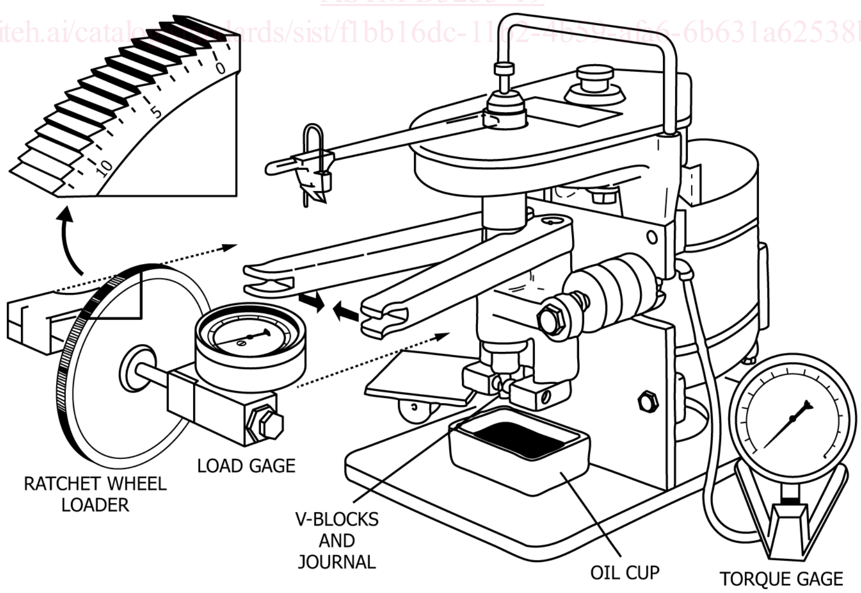


**FIG. 1 Schematic Diagram of Falex Standard Pin and Vee Block Test Machine**

[3] The Falex Pin and Vee Block Test Machine, available from the Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554 has been found satisfactory for this purpose. A new model of this machine has been available since 1983. Certain operating procedures are different for this new model. Consult instruction manual of machine for this information.

[4] Available from Falex Corp., 1020 Airpark Dr., Sugar Grove, IL 60554.

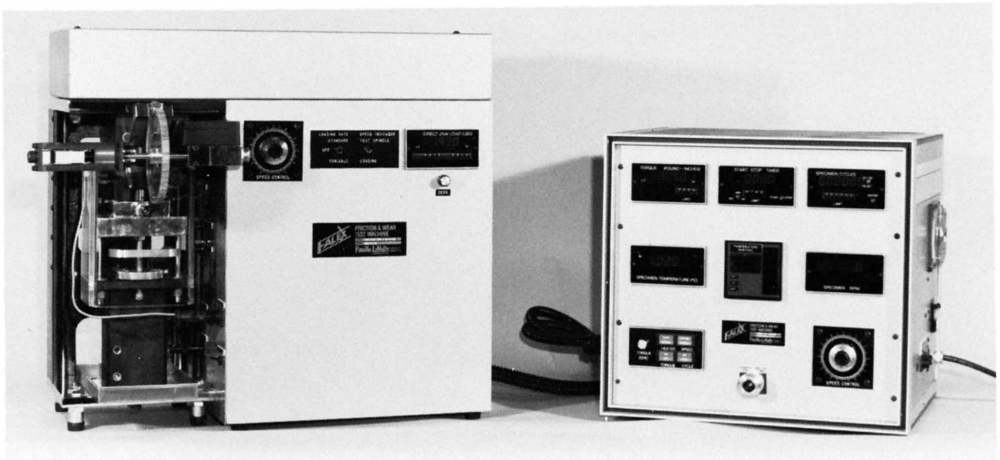

FIG. 2 Falex Digital Pin and Vee Block Test Machine

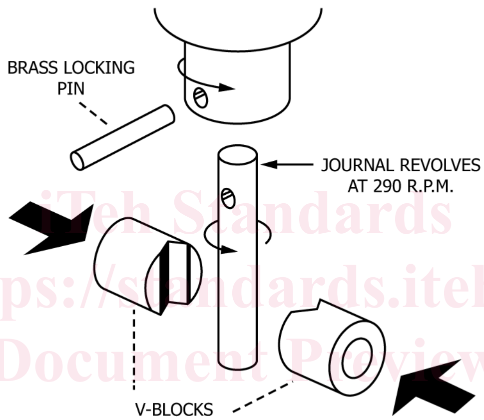




FIG. 3 Exploded View of V-Blocks and Journal Arrangement, Falex Pin and Vee Block Test Machines



6.2.4 *Brinnell Microscope,* or equivalent.

6.2.5 *Timer,* graduated in seconds and minutes.

6.2.6 *Rule,* steel, ~~6-in.~~6 in. (approximately ~~150-mm)~~150 mm) long.

## 7. Reagents and Materials

7.1 *Standard Coined-Blocks,*[4] ~~96~~96° ± 1° angle, AISI C-1137 steel, HRC 20 to 24, surface finish ~~5~~5 µin. to 10 µin. (1.3 × $10^{-7}$ m to 2.5 × $10^{-7}$ ~~m),~~ m), rms.

7.2 *Standard Test Journals,*[4] ¼ ~~in. (6.35 mm)~~ in. (6.35 mm) outside diameter by 1¼ ~~in. (31.75 mm)~~ in. (31.75 mm) long, AISI 3135 steel, HRB 87 to 91 on a ground flat surface, surface finish ~~5~~5 µin. to ~~10 µin.~~ 10 µin. (1.3 × $10^{-7}$ m to 2.5 × $10^{-7}$ ~~m)~~ m) rms.

7.3 *Locking Pins,*[4] ½ H brass, conforming to Specification B16/B16M.

7.4 *Solvent,* safe, nonfilming, nonchlorinated.

NOTE 4—Petroleum distillate and benzene, formerly used as solvents in this method, have been eliminated due to possible toxic effects. Each user should select a solvent that can meet applicable safety standards and still thoroughly clean the parts.

## 8. Preparation of Apparatus

8.1 *Cleaning:*

8.1.1 Thoroughly clean the V-blocks, test journals, lubricant cup, and supports for V-blocks and test journals by washing, successively, with solvent selected in 7.4. Dry the V-blocks, test journals, lubricant cup, and supports by allowing the final solvent to evaporate in air.

8.1.2 After cleaning, handle the test pieces with care to prevent contamination. Particularly, avoid contact of fingers with mating surfaces of V-blocks and test journals.

8.2 *Assembly:*

8.2.1 Insert the test journal into the test shaft and secure with a new brass locking pin, as shown in Fig. 1 and Fig. 3.

8.2.2 Insert the V-blocks into the recesses of the loading device and swing the V-blocks inward to contact the journal so that the V-grooves are aligned with the journal major axis, as shown in Fig. 1 and Fig. 3.

8.2.3 Place 60 mL 60 mL of test lubricant in the lubricant cup and raise the cup so that the V-blocks are immersed in the test lubricant. With highly viscous fluids, open the jaws slightly to ensure that the wear surfaces are covered with the lubricant.

8.2.4 Place the automatic loading device, with attached gage,gauge, on the jaw arms.

## 9. Preparation of True Load Calibration Curve

9.1 On log-log paper (K & E467080 or equivalent) draw a straight-line plot of load, pounds-force (newtons) (ordinate), versus indentation diameter, millimetres (abscissa) using the data points shown below. Label this curve "True Load" (Note 5).

| Load, lbf (N) (Ordinate) | Diameter, mm (Abscissa) |
|---|---|
| 500 (2224) | 2.62 |
| 1000 (4450) | 3.42 |
| 1500 (6672) | 4.00 |
| 2000 (8896) | 4.47 |

NOTE 5—Fig. 3 shows the true-load calibration curve for the prescribed 4500-lbf (20 000-N) gage, prepared as covered in 9.1. Copies of Fig. 4, 8 by 11 in., are available at a nominal cost from ASTM. Although not originally used in development of these test methods, the 3000-lb direct reading load gage should be satisfactory providing results are corrected and reported with respect to the true load (4500-lbf) reference line. Refer to Test Method D2670 for calibration of 3000-lb load gage.

## 10. Calibration of Load Gage 4500 lbf (20 000 N)

10.1 Remove the Allen set screw and ½-in. (12.70-mm) ball from the left jaw socket (Fig. 5).

10.2 Insert the special Allen screw with the attached 10-mm Brinnell ball into the working face of the left jaw. Adjust so that the ball projects about 5⁄32 in. (approximately 4 mm) from the face of the jaw.

10.3 Insert the back-up plug in the counterbore of the right-hand jaw. Adjust so that the plug projects about 1⁄32 in. (approximately 0.8 mm) from the face.

10.4 Support the standard test coupon so that the upper edge of the coupon is about 3⁄32 in. (approximately 2.5 mm) below the upper surface of the jaws. Place a steel rule across the face of the jaws. Adjust the Allen screw with the attached 10-mm ball until the face of the jaws are parallel to the steel rule with the test coupon in position for indentation.

10.5 With the test coupon in position for the first impression, place the load gage assembly on the level arms. Remove the slack from the assembly by moving the ratchet wheel by hand.

10.6 Place the loading lever on the ratchet wheel and actuate the motor. Allow the motor to run until the load gage indicates a load of 500 lbf (2224 N). A slight take-up on the ratchet wheel is required to hold the load due to the ball sinking into the test coupon. After a 500-lbf (2224-N) load is obtained, hold for 1 min for the indentation to form.

10.7 Turn off the machine and back off the load until the test coupon is free of the jaws. Advance the test coupon approximately 3⁄8 in. (approximately 9.5 mm). Additional indentations should be separated by a minimum distance of 2.5 times the diameter of the initial indentation. Check the alignment of the jaws, and repeat the procedure described in 10.6 at gage loads of 1000, 1500, and 2000 lbf (4448, 6672, and 8896 N).

10.8 Remove the load gage assembly and test coupon and measure the diameter of each indentation to 0.01 mm with a microscope. Make three measurements of the indentation diameter, rotating the test coupon to ensure that no two measurements represent the same points. Average the three measurements of each impression and record.

10.9 Plot the four impression readings on the same log-log plot of true load prepared as prescribed in 9.1 and shown as Fig. 4. Draw a straight line through the four impression readings and label the line "Actual Gage Load."

NOTE 6—Currently, load gages are calibrated at the factory such that the actual 4500-lb gage load is equivalent to true load. Periodic calibrations should be made to ensure correct values are being reported for true load.

## TEST METHOD A

## 9. Determination of Actual Gage Load for Run-In

9.1 The procedure, Section 1210, requires a run-in at an actual gage load equivalent to 300-lbf (1334-N) true load (264-lbf direct load). This actual gage load is obtained as follows from the plot of actual gage load and true load prepared in Sections a 300 lbf (1334 N) true load (264 lbf direct load).9 and 10: Locate 300 lbf (1334 N) on the true load curve (264-lbf direct load). Through this point draw a vertical line to intersect the actual gage load curve. Through this point of intersection draw a horizontal line to the left-hand or right-hand load scale and read the actual gage load value. Record this actual gage load for run-in on a suitable reporting form.

NOTE 5—Newer instruments use electronic calibration for true load and do not require calculation and plotting of true load versus gauge load curves. For older machines these calculations are in Appendix X3 and Appendix X4.

NOTE 6—A suitable reporting form for Test Methods A and B, and data obtained on one of the ~~reference~~ fluids by one of the cooperating laboratories, is shown in Table ~~3~~1.~~Fig. 6 shows the calibration curves used by the laboratory reporting the data in Table 3.~~

## 10. Procedure

10.1 *Run-In:*

10.1.1 Turn on "Heat Control" switch and heat test lubricant to ~~120~~120 °F ± ~~5°F (48.89~~5 °F (48.89 °C ± ~~3°C);~~3 °C); then turn off the switch.

10.1.2 Remove slack from assembly by moving the ratchet wheel by hand. At this setting the torque ~~gage~~gauge should read zero, or be adjusted to zero.

10.1.3 Actuate the motor, engage the automatic loading ratchet, and increase the load to ~~a gage load equivalent to 300-lbf (1334-N) true load (264-lbf direct load), as determined in~~ 300 lbf (1334 N) true load (264 lbf direct load). ~~8.1.~~ Disengage the loading ratchet, start the timer, and allow the machine to run at this loading for a ~~5-min~~5 min run-in period.

NOTE 7—Maintain load at near constant by taking up the load manually or automatically by means of the ratchet wheel if necessary.

10.2 *Test:*

10.2.1 Re-engage the automatic loading ratchet and leave it engaged until failure (Note ~~9~~8) ~~or until the highest indicated actual gage reading is reached. Stop the~~ and stop the motor at failure or at the highest indicated actual ~~gage~~gauge load when no failure is obtained. ~~Record the gage load at failure. Record 4500 lbf (20 000 N) if no failure is obtained.~~

NOTE 8—Failure is indicated by (*a*) breakage of shear pin or test pin, or (*b*) inability to take up the load automatically by means of the ratchet wheel.

10.2.2 ~~Using the calibration curves prepared in Sections~~ Record the ~~9 and 10, determine and record the true load failure equivalent to the actual gage load~~ true load failure, or, if no failure, the true load ~~equivalent to the highest indicated actual gage load,~~ with a plus ( + ) sign after the true load value.

~~NOTE 10—To convert actual gage load to true load, locate the gage load on the actual gage load curve. Through this point draw a vertical line to intersect the true load curve. Through this point of intersection draw a horizontal line to the left-hand or right-hand load scale and read the true load value.~~



### TEST METHOD B

## 11. ~~Determination of Actual Gage Load for Run-In and 250-lbf (1112-N)~~Run-In and 250 lbf (1112 N) True Load Increments

11.1 The procedure, Section ~~14~~12, requires a run-in at ~~an actual gage load equivalent to 300-lbf (1334-N) true load (264-lbf~~300 lbf (1334 N) true load (264 lbf direct load), and testing at incremental ~~gage loadings equivalent to 250-lbf (1112-N)~~



**TABLE 1 Suggested Report Form, Test Methods A and B, Showing Data**

Operator: Laboratory A
Test Sample: L-XI-1-2-E
TEST METHOD A
Run-In: 5 min at 300 lbf true load.

| | True Load, lbf at Failure |
|---|---|
| Test No. 1 | 2100 |
| Test No. 2 | 1925 |

TEST METHOD B
Run-In: 5 min at 300 lbf true load.

| True Load, lbf | Test No. 1 | Test No. 2 |
|---|---|---|
| 500 | pass | pass |
| 750 | pass | pass |
| 1000 | pass | pass |
| 1250 | pass | pass |
| 1500 | pass | pass |
| 1750 | pass | fail |
| 2000 | pass | |
| 2250 | fail | |
| 2500 | | |
| 2750 | | |
| 3000 | | |
| 3250 | | |
| 3500 | | |
| 3750 | | |
| 4000 | | |
| 4250 | | |
| 4500 | | |

250 lbf (1112 N) true load (224-lbf(224 lbf direct load) over the range from 500500 lbf to 4500-lbf (22244500 lbf (2224 N to 20 000-N)20 000 N) true load (412(412 lbf to 2885-lbf direct load). Determine the equivalent actual gage loads as prescribed in Section 2885 lbf direct load). 8, and Test Method A. Record on a suitable reporting form, such as shown in Table 31.

## 12. Procedure

12.1 *Run-In*—Use the same procedure as prescribed in 12.110.1, Test Method A.

12.2 *Test:*

12.2.1 Re-engage the automatic loading ratchet and leave it engaged until the actual gage reading is equivalent to 500-lbf (2224-N) true load (412-lbf direct load), as determined in Section 500 lbf (2224 N) true load (412 lbf direct load). 13. Run for 1 min at this loading.

NOTE 9—Maintain load at near constant at this load and at subsequent incremental loading by taking up the load by means of the ratchet wheel when necessary.

NOTE 10—Keep the motor running after run-in and throughout subsequent loadings.

12.2.2 Increase actual gage loads in the increments equivalent to 250-lbf (1112-N) true load (224-lbf direct load), as determined in Section load by 250 lbf (1112 N) true load (224 lbf direct load), 13, running for 1 min at each increment loading. Record the load at which failure occurs (Note 1412, Note 1513). If no failure is obtained, record the last load run with a plus ( + ) sign after the value.

NOTE 11—Failure is indicated by (*a*) breakage of shear pin or test pin, or (*b*) inability to increase or maintain load by means of the ratchet wheel.

NOTE 12—If failure occurs during run-up between load increments, record the higher increment load as fail.

14.2.3 Determine and record the true load failure equivalent as described in 12.2.2.

### TEST METHODS A AND B

## 13. Report

13.1 Report the true load value at which failure occurred.

13.2 If no failure is obtained, report the last true load run, with a plus ( + ) sign after the value.

## 14. Precision and Bias

14.1 The precision of these test methods as determined by statistical examination of interlaboratory results is as follows (see Note 1513):

14.1.1 *Repeatability*—The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

Test Method A, 27 % of the mean
Test Method B, 24 % of the mean

14.1.2 *Reproducibility*—The difference between two, single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

Test Method A, 40 % of the mean
Test Method B, 43 % of the mean

14.2 *Bias*—The procedure in this test method has no bias because the value of the Falex Extreme Pressure Failure Load can be defined only in terms of a test method.

NOTE 13—The precision data were derived from results of cooperative tests on L-XI-1-2-A, B, C, D, and E, covered in Table 1X2.1 and Table 2X2.2. These are the same reference fluids used and described in Test Method D2783.

## 15. Keywords

15.1 extreme pressure; Falex Pin and Vee Block; load-carrying; lubricant; wear